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Electric Fixtures and Shades.

As articles published from time to time in this journal bear evidence, there has been a gradual improvement in the means for utilizing electric light. But the more we have the more we want, and it is a fact, too, that conditions have changed very widely since the days when they used to wire old gas fixtures and let it go at that. In the first place, people have learned freedom of location in installing lights, unhampered by the mistakes of the past and, what is more important, they have learned, to a certain extent, that with the intense brilliancy of modern illuminants, both gas and electric, has come a necessity for screening them from the unobstructed field of the eye. In spite of this common knowledge, the deadly inertia of human habits has made improvement very slow. And what is worse in its effects, a petty economy is too often allowed to stand in the way of progress. Any fool can light a room brightly; it takes skill to so light it that one can see comfortably therein. If brightness is the sole criterion of interior illumination, then the use of all shades is objectionable as tending to waste the energy applied to the purpose by cutting off a little light. Hence the evil ministrations of those who seek to save a few pennies by using bare incandescent lamps or unshaded Welsbachs on the theory that the brighter the lamp looks the better it is. Unhappily this sort of illumination is cheap, requiring little skill and small expenditure for fixtures, and when buildings are put up on the cheapest possible basis cheap wiring after this manner is unhappily the rule. The worst enemy of proper illumination is the jerry builder and his understudy, the scamping contractor. Next to him in bad pre-eminence comes the architect with a case of artistic swelled-head and profound ignorance of technical matters. The architect seldom makes the mistake of lighting too brightly, but if left to himself he often makes it difficult to see at all.

To come down to concrete matters, proper lighting requires very judicious choice of fixtures and often demands material which can at present be found on the market only too rarely. Suppose, for instance, that one is going to light a large room with incandescent lamps, under the requirement often met in offices that the illumination shall be fairly good all over the room. It is easy enough to furnish a sufficient quantity of light, but when it comes to the details of installation one is often hard pressed to accomplish some very simple things, save by a great sacrifice of efficiency. For example, it is a well-known fact that an incandescent bulb, even if frosted, is still too bright to be left in the field of vision. Most people have unpleasant memories of some time of trial with an unavoidable lamp glaring straight into the eyes, and consequent inflammation. Now one would suppose quite off hand that plenty of shades fitted to entirely conceal the bright filament could be found on the market, but such is by no means the case. Most shades are far too shallow to conceal the lamp unless they are of the "artistic" variety that obliterates the light as well. There are, of course, globes that entirely cover the lamp, in most instances either showing the blazing filament or letting the light through in brilliant streaks and spots. Little study has been made of the proper degree of translucency—great enough to make the loss of efficiency moderate and little enough to leave no obtrusive bright spots. Even the humble sand-blasted ball is rarely just right in translucency, easy as it is to make it so. The requirement is uniform diffusion without needless loss of light, and area enough in the shade to keep down the intrinsic brilliancy. The human eye in natural illumination is seldom exposed to local brightness at all comparable to the 5 or 10 candle-power per square inch of surface often found in artificial light.

The light received in an ordinary room from the windows may give the effect of brilliant illumination, while in point of fact the aperture effective in producing the result is of very low brilliancy per unit of area, as when one gets an illumination of 5 or 10-foot candles on his desk from a neighboring window, perhaps four feet by six. In the better class of lighting fixtures provision is often made for excessive and very irregular screening. The commonest mistake in design is to take into sole consideration the effect produced when the light itself is not in use. At one time cut glass, perhaps the worst imaginable material for a shade, was a favorite with the architects. This has in a measure gone by, but lamps in imitation of candles and wrought lanterns with brilliant apertures that leave a vicious after-image on the retina are still only too common. The coming of small arc lights, gas "arcs" and the recent high-efficiency incandescent lamp increases the difficulty of proper shading enormously, and those who plan the lighting of buildings ought to take this into serious consideration. The gas "arcs," useful and economical as they are, have globes which show several times too great intrinsic brilliancy to be tolerated by the eye, and the same is true of most electric arcs used in interior work. Every oculist can report a long list of serious injuries directly traceable to the indiscreet use of modern illuminants. Proper lighting is not alone a function of the engineer—it is a subject with which every builder ought to make himself somewhat familiar, to avoid falling into errors that may be very troublesome to correct when the building is completed. The judicious placing of outlets is of great value in facilitating their effective use, yet one very commonly finds that a false economy has left very insufficient opportunity for good lighting. When the fixtures are considered, one must not forget that proper location and shading are competent to produce the required results at greatly lowered cost of operation. It is poor economy to save a few dollars in the original cost of installation and thereby to compel the constant use of two lamps where one should be amply sufficient. The mere dollar-and-cent side of the question is important. If some one brings out an illuminant of even slightly increased efficiency there is immediate interest aroused, and the saving of equal energy by skillful use ought to be equally appreciated.

Bearing Capacity of Earth Foundation Beds.

In the issue of The Engineering Record of Dec. 8 a brief reference was made to the highly interesting work recently done by Dr. E. L. Corthell in collecting and analyzing the pressures on the foundation beds of certain stable structures. The pressures per square foot to which reference was made are those existing upon what may be called earth foundations, the term "earth" comprising a wide range of materials from that which is little better than stiff mud up to classes of hard clay and gravel nearly equivalent to rock. Although such data, however carefully compiled, include many determinations of questionable value in consequence of uncertain methods of computation, on the whole the results are probably as reliable as could be expected. Computations of actual loads upon foundation beds are never better than closely approximate, and that approximation in many cases shades out into degrees of much uncertainty. Fairly good authority can be found for supposing that pressures as high as 22,000 to 28,000 lb. per square foot are supported on a bed of fine sand under the Washington Monument, but it would probably be a matter of some difficulty to establish either one of those values with any high degree of accuracy, even under the wind pressures in consequence of which the higher of those pressures is supposed to be produced.

Dr. Corthell has rendered the profession a real service in correlating these foundation data, but it is necessary to observe that any such collection of values must, like many other engineering data, be used under the guidance of a well trained judgment. Foundation pressures are to some extent rather erratic in their manifestations, even if it were possible to determine their exact amounts. It is assumed, for instance, in probably all computations usually made to determine pressures that they are either uniform over the entire foundation bed or parts of the bed, or that if they vary the law of uniform variation of intensity controls them. Any experienced engineer is perfectly well aware that neither of these laws necessarily holds, but that they must be assumed as the only workable hypotheses available. In other words, if such laws are not assumed no others can be found to take their places. It is altogether probable that no serious errors are committed in employing such procedures, but it is absolutely necessary for a safe and reasonable treatment of foundation problems that their real nature be recognized. Again, great care should be taken in the interpretation of results. The mere fact that 12,000 or 15,000 lb. per square foot are safely carried by a bed of sand in one location does not justify any such loading as a general rule. There are many places where such loading should be restricted to an amount not greater than 5,000 or 6,000 lb. per square foot. These observations hold especially with regard to conditions which may be introduced by deeper excavations in the immediate vicinity of an already completed foundation.

The depth of excavation at which a building is founded upon sand, gravel, clay, or other similar material is a most important element, and the results of a recorded safe loading per square foot on such material has little meaning unless accompanied by a full statement of the depth below the surface as well as the nature of the loading applied, also whether the foundation excavation has not created a new surface at a still deeper level, in fact nearly down to the foundation bed itself. Almost any material when not too wet will carry a high foundation load if it is prevented from moving laterally, and a recorded foundation load loses its substantial significance in the absence of information regarding all these collateral conditions.

Again, many engineers properly make the rational distinction between total load upon a foundation bed and the abnormal load; i. e., the load per square foot in excess of that which the same foundation bed carried prior to any disturbance of the material above it. As a matter of fact the abnormal load is really the significant load. Clearly any square foot of area, unless surrounding conditions are radically changed, will safely carry a load equal to that imposed on it by the mass of natural material resting upon it before being disturbed. The real, essential question is, then, how much in addition to that natural load may safely be imposed. If the material is not too moist to permit a reasonable application of the theory of earth pressure to the case, the computed supporting power corresponding to the abutting force of the adjacent material will convey some idea of the abnormal load to which it may properly be submitted. The results of such computations, however, must be qualified, like all others of the same class, by good engineering judgment. If the material is wet or otherwise questionable, recourse must be had to the safe loads imposed by other structures under similar conditions or to the best engineering guess that can be made under the circumstances.

It is seen, therefore, that much more information is really needed in analyzing and digesting precedents of safe foundation loads than their amounts only. The latter must be most carefully regarded in connection with the surrounding conditions and what is meant by the loads themselves. The effect of water in the supporting material, the depth below the "surface" of the deepest excavation, the character of underlying strata, the conditions under which structures similarly circumstanced have settled and other influences which would easily swell into a long list, are as important elements of the general problem as the amounts of loading themselves.

There is another case of foundation loads which, if included in his data, would have added materially to the interest and importance of the results set forth by Dr. Corthell, and that is the type which has been called "mud flotation." This class of foundations is widely extended and is found wherever mud exists to great depths and is well illustrated by some of the water-front work of Manhattan Island. Where mud exists to the depth of 100 or 150 ft. or where it is obviously impracticable to reach hard material by long piles, it then becomes essential to use a pile foundation with a great depth of penetration, perhaps 60 or 70 ft. or more, so that the weight of the superimposed structure is distributed over a large area of thick mud by the frictional resistance against the skin of the piles. It would be interesting as well as important to ascertain the safe average pressure per square foot if distributed over that kind of an area. It is probable that many loads running from 500 to 1,500 lb. or more per square foot are safely carried, but the absence of anything like complete and accurate analysis does not permit any definite statement to be made. This class of foundation work, however, is one of great importance, and if a comprehensive study were made of many safe existing cases results of great value would be disclosed.

Tests of Shear in Concrete.

The determination of the resistance to shear offered by structural materials is a very troublesome task on account of the experimental difficulties which arise through the necessity of eliminating tension and compression influences. It is, of course, a simple enough matter to cut off a bar by an apparatus working like a steel shear or to punch it by means of a die in a press, but the results of such operations do not give more than a very approximate indication of the true resistance of the material to shear unless the test specimens and apparatus are specially designed and skilfully used. The determinations of the shearing resistance of mortar and concrete, for example, have given widely varying results, which cannot be attributed entirely to the different qualities of the concrete test pieces employed. On account of the uncertainty which now exists regarding this property of concrete, the experiments recently made at the Engineering Experiment Station of the University of Illinois by Messrs. C. S. O'Connell, J. E. Shoemaker, J. E. Schoeller and N. E. Seavert are of unusual value, which is enhanced by the very clear discussion of them by Prof. A. N. Talbot in a recent Station bulletin.

The necessity of distinguishing shear from bearing pressure, beam action and other phenomena accompanying shearing tests is generally recognized, but the difficulty of doing it has usually led to various assumptions concerning the internal stresses and strains in test pieces that are certainly not correct and may be very incorrect. For example, the jaws of shearing blades are generally bevelled, so that when a piece is cut by them there is an unequal distribution of pressure on these bevelled surfaces and both tensile and compressive stresses result. In Feret's experiments the specimen was clamped and then a single shearing blade with a bevelled edge was employed to cut off the piece; this method manifestly had the same defect as an ordinary pair of blades. In other cases, the blades have been so narrow as to produce crushing rather than shearing when pressure was applied to them. In still other tests, like those of Zipkes, the specimen was subjected to so much flexure that the shear was masked. Some of the best tests were those made last year at the Massachusetts Institute of Technology. The specimens were cylinders 5 in. in diameter and 15½ in. long. The ends were securely clamped in cylindrical bearings and the load was applied along a length of 5 7/16 in. of a semi-cylindrical bearing block. This method of testing permitted the bar to break first as a beam, but the final failure was by shear.

In the experiments conducted at the University of Illinois much study was directed to the development of a method of testing which would eliminate tensile, bearing and web stresses. Prof. Talbot points out that this study was not entirely successful and acknowledges that the methods used and the forms of test pieces adopted are open to objection, but an examination of his report on the investigation will show that it is a very important one notwithstanding his own criticism. Not the least interesting feature of the work was the use of two entirely distinct methods of testing. In the first a hole was punched in a concrete plate or block, while in the second a short concrete beam restrained at the ends was broken. The results are of general value when studied collectively, but a careful examination of them individually shows that the influence of other stresses than shear was clearly evident. Prof. Talbot suggests the use of a test specimen in the form of a beam loaded evenly over its depth instead of its top, but speculation concerning its advantage is of little value as compared with actual experience with it, which alone can determine its worth. The importance of securing some satisfactory method of making shearing tests ought to lead to an early trial of this proposed side-loaded bar.

The general results of the experiments confirm those of Feret at the laboratory of the French Bureau of Bridges and Highways and those of Prof. Spofford and the Joint Committee on Concrete and Reinforced Concrete at the Massachusetts Institute of Technology, but they are considerably higher than the values suggested by other experiments. The full data regarding them are given in Prof. Talbot's report, so it is unnecessary to mention more than his general conclusions from them. They indicate that the shearing resistance of concrete depends on the strength of the stone as well as that of the mortar, and in rich mixtures the stone seems to exercise a greater influence than the mortar. Concrete 60 days old, made of hard limestone and mixed 1:3:6 will have a shearing resistance of about 1,100 lb., and a 1:2:4 mixture a resistance of about 1,300 lb.; Prof. Talbot is of the opinion that when some accurate means of measuring simple shear is invented the results will be above rather than below the figures given. One interesting point brought out by the tests is that the practice of expressing the shearing strength of concrete as a percentage of the compressive strength is hardly justifiable, for the former is influenced largely by the strength of the aggregate and the latter by the strength of the mortar. It is frequently done, however, and the results of the University of Illinois tests show that the shearing strength is generally at least 50 per cent. of the compressive strength and may exceed 75 per cent. This is an important fact, because it is often asserted on the strength of tests by Bauschinger, Mesnager and others that the shearing resistance is very much less.

A New Trunk Railway.

The construction of the Tidewater and Deepwater Rys., which form a trunk line 446 miles long, from tidewater near Norfolk, Va., across the southern part of Virginia to and through the center of the richest coal fields of West Virginia, is one of the most important features of railroad engineering of our time, as well as an interesting event to purchasers of steam coal. The location of these railways, the standards adopted for their construction and the methods followed in the construction work will be described fully in a series of articles begun in this issue. Exceedingly good grades and alignment have been secured, the standards of construction are high, and the work has been carried on since the inception of field operations with an unusually large plant and force. The Kanawha, Pocahontas and New River coal fields, tapped by these railways, are of great richness and magnitude. Although extensive mining operations have been carried on in them for many years and the annual producing capacity of mines in them is in the neighborhood of 25,000,000 tons a year, only comparatively small portions of the fields have been developed. The Deepwater Ry. passes through the center of their undeveloped sections, and has directly tributary to it more than 1,000,000 acres underlaid by three to five workable seams of excellent coal. The trunk line has been built primarily to provide facilities by which this coal may be most economically transported to tidewater and to connections with the great railroad system crossing the eastern part of Virginia.

The country in which the coal fields exist is practically all composed of disconnected mountains, jumbled closely and irregularly together in such manner as to make railway location and construction particularly difficult. Unlike the existing railroads that reach and pass through this country in the few more or less regularly defined stream valleys, the Deepwater Ry. has, generally speaking, been located across a broad tableland at the headwaters of the streams that have their sources in these mountains. This method of location has naturally involved heavy and expensive work, but it permits the extension of branches from the main line at water grades for considerable distances, which is an uncommonly strong factor in the location of a railway through these coal fields.

The location and grades from the yard at Princeton, where traffic from all branches will be assembled, to the tidewater terminal at Sewall's Point near Norfolk, in a distance of 350 miles, are the most remarkable features of the whole project. That a 0.2 per cent. compensated grade against eastbound traffic and a 0.6 per cent. compensated grade against westbound traffic have been secured, with two exceptions, in crossing the main ranges of the Allegheny and the Blue Ridge Mountains, to say nothing of the rough, rolling country in central Virginia, indicates the character of the line that is being built by these companies. The two exceptions to these grades are not of serious consequence, as they are short and as two locomotives can handle the same trains over them that can be hauled by one locomotive over the remainder of the 350 miles. The manner in which the prevailing grades have been balanced in order that traffic can be handled most economically is also a feature which has probably never before been so completely developed on a new railroad extending over such distances.

The location of the tidewater terminal at Sewall's Point on Hampton Roads near Norfolk is a particularly advantageous one. This location secures a terminal which vessels of the deepest draft can readily reach at low tide. The terminal is also situated so it will probably never be in a congested district, and at the same time the immediate approach to it on the land side is made through country that will remain free from complications with other transportation facilities for many years, with a probability that such complications will never arise.

The amount of contractor's plant and the size of the contractors' forces employed in building these railroads may readily be appreciated from the descriptions of the work. There have been few instances of railroad construction where such extensive installations of plant have been made, where so many men have been employed, or where work has been under way at so many points at the same time. The contracts for the western end of the Deepwater Ry. which were awarded some time ago are, for the most part, completed. The contracts for the eastern end of Tidewater Ry. were awarded in 1904 and are also largely finished. Grading is now in progress simultaneously on all of the uncompleted portions of the remaining 275 miles of the two railroads, and is being carried forward with unusual rapidity, indicating that the entire line will be in operation not much over a year hence.

Various unfounded rumors have been circulated that the Tidewater and Deepwater Rys. are a part of existing systems, or at least are being constructed by interests controlling such systems. As a matter of fact, they form an entirely independent trunk line which is being built to handle traffic from the West Virginia coal fields to eastern connections and to tidewater. The location of the Deepwater Ry. is such, however, that it can be extended very readily to the Ohio River on water grades from several points, and, of course, further extension to the Great Lakes is a simple matter as compared with the work that has been undertaken. At any rate, the opening of the portion of these railroads now under construction will have a great effect on the coal output of West Virginia and on the bituminous coal market in the eastern part of the United States.

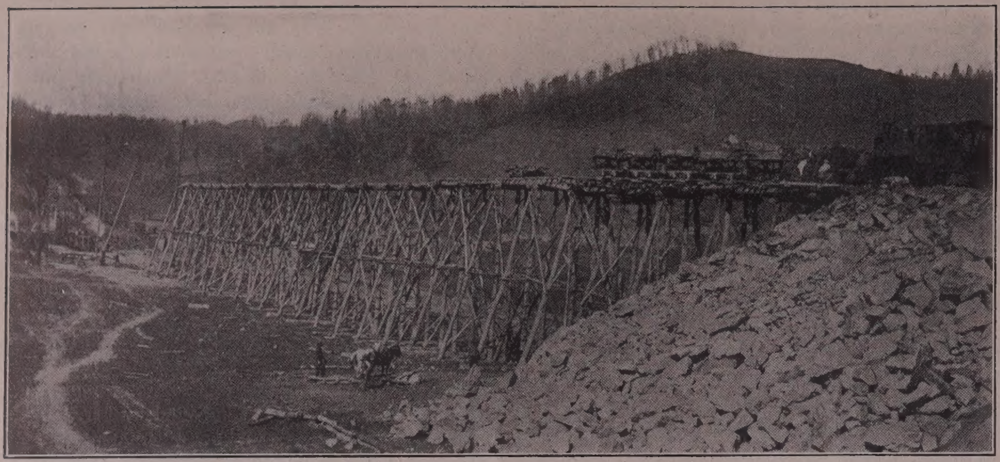
Notes and Comments.

The Salton Sink and the Imperial valley in Southern California are again threatened with inundation by the Colorado River. A few weeks ago the break in the river bank through which water had poured into this depression for many months was finally closed, and it was believed that this rich district was safe from the danger threatening it. The valley lies lower than the Gulf of California, into which the river discharges, and is saved from inundation only by the tightness of the river bed, which is apparently due to the silting-up of its pores. One of the banks was considerably disturbed by the construction of the headworks of an irrigation canal and a cravasse was formed in it that required an enormous expenditure and many months of hard work to close. It now seems that while these dikes themselves were strong enough they have been undermined, and the task of controlling the river must again be taken up. The insidous working of water has rarely been shown more forcefully than at this crevasse, and the importance of the interests which it threatens makes the history of the break and the efforts to repair it an instructive chapter in current engineering affairs.

The Surveying Work on the north tube of the twin tunnels from the Battery, in Manhattan, under the East River to Brooklyn, has been very accurately conducted, in spite of the difficulties due to curvature, locks and bulkheads. On Dec. 7, when the two shields of the north tube were about 90 ft. apart, the advance of the Brooklyn shield was stopped and an extra-heavy 6-in. wrought-iron pipe was started near the bottom of the shield toward that working from the Manhattan side. Special precautions were taken in getting this forward to keep its alignment correct. It took about 24 hours to force the pipe through, of which four hours were occupied in getting started and four hours were lost on account of the breakdown of the pump used in jetting. When it emerged at the Manhattan shield it was not truly on the center line, but was straight enough to see through and was only an inch or two out of level. The lines and grades were checked by means of the pipe and were found to practically coincide. The line from the Battery shaft had been carried about 2,400 ft. and that from the Brooklyn shaft about 3,100 ft.; these lines were produced in the usual way from wires suspended in the shafts, the base between the wires being about 12 ft. The work was done under the direction of Mr. F. C. Noble, division engineer of the Rapid Transit Railroad Commission. Mr. D. H. Hough, president of the New York Tunnel Co., the contractors for the Battery tunnel, stated early in the week that the two shields would probably meet within a few days, while the south tube shields, which were intentionally kept behind the others, would meet in about six weeks.

Double Filtration will be adopted at the Albany, N. Y., water-works, and plans for the preliminary filters for this purpose, to prepare water for the existing filters, were worked up some time ago by Mr. Wallace Greenalch, superintendent of the Bureau of Water. The contract for their construction would have been let before this had the site for them been prepared early enough to permit any work to be done this season. Some very interesting experiments conducted by Mr. Greenalch show that after 12 hours' sedimentation of the raw water, it has been feasible to treat it by preliminary filtration, without coagulants, at a rate of 85,000,000 gal. per 24 hours, and obtain an effluent that can be filtered satisfactorily by the present plant at the rate of 6,000,000 gal. per day. The number of bacteria in the final effluent with this double filtration has been found experimentally to be much less than that obtained now with single filtration, particularly during the winter months. It is believed that in addition to giving water of a better quality than can be furnished by the present method, double filtration will be considerably less expensive.

The Victoria Falls Power Scheme, which has aroused so much discussion in England and on the Continent, seems likely to be tried, for the British South Africa Co. has placed a contract with the Allgemeine Electricitäts Gesellschaft for the equipment for this great undertaking. It is generally acknowledged that it is practicable technically to transmit electricity from the falls of the Zambesi to the Rand, some seven hundred and fifty miles distant, but the financial aspect of such an undertaking appears unattractive to most of the engineers who have investigated it. This is particularly evident from the fact that coal in large quantities occurs on the Rhodesia Ry. at a locality some distance south of the Falls, and steam power is accordingly likely to be reduced in cost in the Rand as the coal mines are developed and transportation facilities improved. The astonishing feature of the project in its present form is that the original intention of supplying 20,000 or 25,000 h.-p. from the Falls has been magnified into a scheme which contemplates supplying 150,000 h.-p. before long. This great amount of power can be furnished at a profit at low rates, the promoters apparently estimate, and thus a transmission plant can be made profitable when one furnishing less current will be a financial failure. Whether it will be possible to sell so much power in the Rand in competition with steam is certainly open to question, for it is over half of the present power requirements of the district. A very large part of the fixed charges of such works are represented by the investment of transmission line material, which it is proposed to reduce to a minimum by using a single set of conductors. To guard against interruption of service it is proposed to have at Johannesburg a storage battery equipment large enough to carry full load for twelve hours, and to supplement it with a 20,000-h.-p. steam station as a reserve. The undertaking is the boldest electrical power project yet started, and if it should prove financially successful a great many opinions concerning hydraulic development and long-distance power transmission will need revision. For the present, however, there is no call to begin such revision, for there are a good many intervening steps to be taken between awarding contracts for equipment and meeting operating and fixed charges when the plant is in commercial operation.



Temporary Trestle for Fill Across Bluestone River Valley.

THE DEEPWATER AND TIDEWATER RAILWAYS.—I

The Deepwater and Tidewater Railways have under construction 445 miles of standard-gauge single-track railroad of the most modern type, extending from tidewater at Norfolk, Va., in an almost direct east and west line across the southern part of Virginia to the West Virginia line, and then northwest and north through the latter state to Deepwater at the head of navigation on the Great Kanawha River. These railroads are being constructed primarily to develop very large portions of the rich and extensive coal fields of West Virginia which have thus far remained practically unopened. For that reason they are being built with the object of handling in the most economical manner the bulky and heavy traffic tributary to a railroad carrying a large amount of coal over long distances. The general scope of the coal fields of West Virginia is shown in outline on the accompanying map. These fields are divided into practically three areas: the conglomerate coals, usually known as the New River and Pocahontas smokeless coals; the Kanawha coals, of which grades adapted to various uses exist, and the Pittsburgh coals, which are the same as the Western Pennsylvania coals. Generally speaking, the Tidewater and Deepwater Rys. will tap the New River, Pocahontas and Kanawha coal fields, the chief portion of the workable areas of Pittsburgh coals in West Virginia occurring to the west and north of the lines of these railroads now being built.

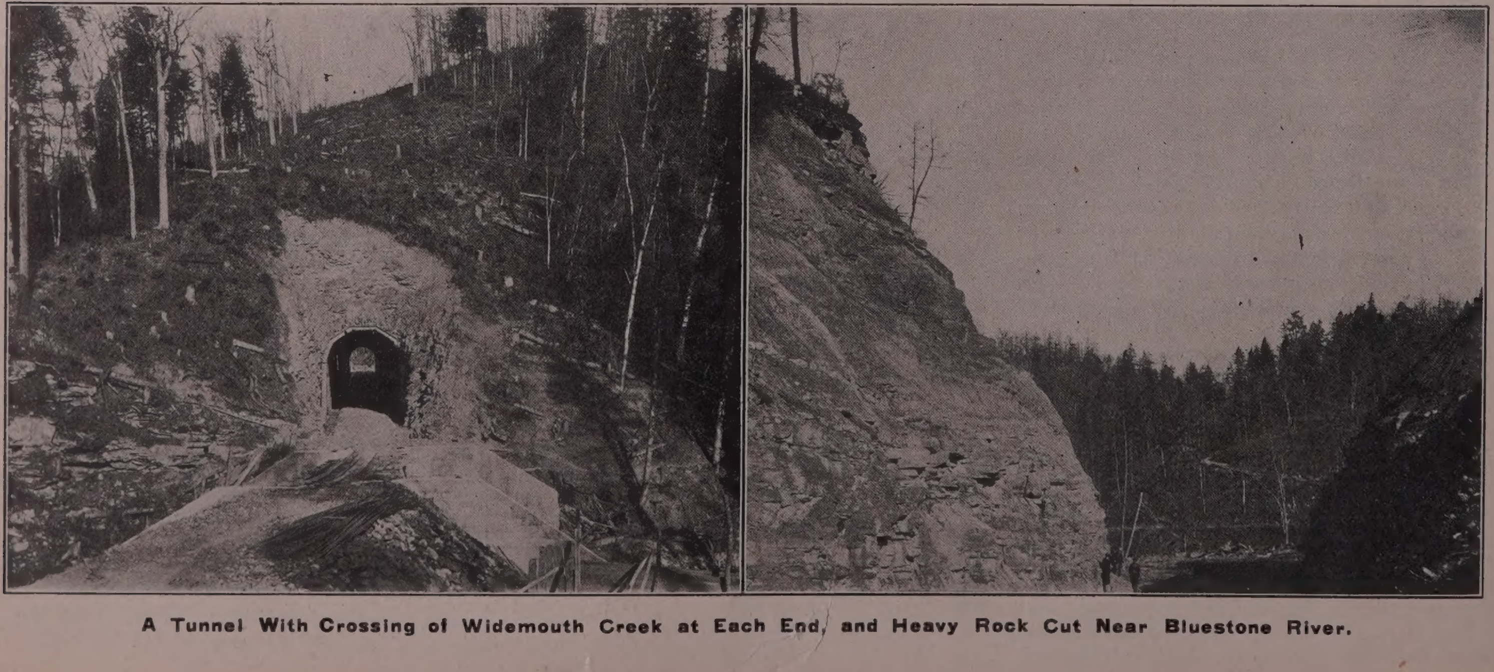
The New River and Pocahontas smokeless coals have become the standard maritime fuel of the world. These coals are higher in fixed carbon and lower in ash than any steam coal produced in this country and they have only 18 per cent. volatile matter as compared with 35 per cent. volatile matter in Pittsburgh coals. Cokes made from them have as low as 5 per cent. ash and 0.5 per cent. sulphur. The Kanawha gas coals produce the very best quality of gas. In the same fields high grade foundry cokes similar to those made from the Pittsburgh coals in the Connellsville district, although lower in ash and sulphur, are produced. It is also commonly known that other grades of Kanawha coals cannot be excelled for domestic purposes. The coals of these various good qualities are not confined to any one part of the fields in which they occur but are found distributed in a remarkably even manner over the entire area.

The New River, Pocahontas and Kanawha fields have thus far been tapped by two railroads only, the Chesapeake & Ohio R. R. across their northerly parts and the Norfolk & Western R. R. across their southerly parts. Although both of these railroads have for years been expending millions of dollars in rectification of alignment, elimination of grades and for additional equipment, they have never been able to keep pace with the increase in coal output due to the development of existing mines and to the opening of new ones. There exists in West Virginia a very great excess of mining capacity over transportation facilities, considering only those mines in actual operation, and it is safe to say that the nearly 700 mines now being operated can produce practically twice the tonnage all of the railroads in the state can possibly haul. With these existing conditions, and in view of the fact that the annual increase in the consumption of coal in this country during 1904 and 1905 exceeded the annual production of any state except Pennsylvania, it may readily be seen that it is practically impossible for whatever progress could be made in existing transportation facilities to keep pace with the extension of operations and the growing demand for coals.

Construction of Coal Carrying Roads.—The topography of the territory in which these coal measures exist prevents the construction of railroads except at tremendous expense. The coal fields for the most part are in exceedingly rough and broken country largely made up of disconnected mountains with occasional ridges that are more or less continuous. The most practicable manner in which to construct a railroad in a country of this character that will tap these fields is to build a main line across them and from this main line extend numerous branches from 5 to 50 miles in both directions.

The main line of the Chesapeake & Ohio R. R. enters the coal fields practically at Hinton where it joins the New River. This road follows that river until the latter joins with the Gauley River to form the Great Kanawha River, which stream the Chesapeake & Ohio R. R. closely parallels to a short distance west of St. Albans. That portion of this railroad from Quinnimont, just west of Hinton, to St. Albans extends directly across the New River, Pocahontas and Kanawha coal fields, being 31 miles in the first two and 57 miles in the latter. After joining New River the main line of this railroad is practically without interruption in a canyon whose sides are from a few hundred feet to a mile apart. Branches extend from this main line up the valleys of various streams tributary to this canyon, but on account of the rapidity of fall in these valleys many of these branches rise on from 2 to 4 per cent. grades and even at those grades they cannot be extended, except in a few cases, to any great distance before they run into the ground. One of these branches which follows up Dun Loup Creek for some distance on a 3½ per cent. grade is said to contribute in the neighborhood of 40 per cent. of the New River coal hauled over this railroad.

The main line of the Norfolk & Western R. R. strikes the coal fields at the Bluestone River and within the immediate vicinity of this junction has branches which contribute a large amount of its



A Tunnel With Crossing of Widemouth Creek at Each End, and Heavy Rock Cut Near Bluestone River.

total coal traffic. These branches extend up various creek valleys until limiting grades are reached. Among these branches is the one to Pocahontas, the one up Elkhorn Creek and a little further to the west the one up Tug River. The main line continues generally westward along the waters of the Tug Fork of the Big Sandy River and just south of a continuous range of mountains known as Indian Ridge, until it leaves the coal fields. It has a total length of approximately 40 miles in the New River and Pocahontas fields, the Kanawha fields not being at their height this far south.

The present main line of the Deepwater Ry., which is that part of the Deepwater and Tidewater Rys. in West Virginia, starts at Deepwater on the Kanawha River and extends 85 miles to the south through the coal fields, with the Kanawha fields to the west and the New River and Pocahontas fields to the east. In practically all of this 85 miles, the line is above the top of the canyons and crosses the headwaters of the northwardly and westwardly flowing streams on a broad table land. At various places tunnels have been driven through disconnected spurs of mountains and in other places long, high steel viaducts have been erected to keep the grades within operating limits or to cut across from the valley of the head waters of one stream to join the valley of the head of another.

A Typical Coal Mine Development.—From Deepwater, the line follows up Loup Creek for 20 miles to a summit of Silver Gap. Seven miles from Deepwater, at Page, is a coal development such as may be expected to take place at many places in the coal fields along the main line of the Deepwater Ry. and its branches. This development has been carried out and is operated by the Loup Creek Colliery Co., Mr. John Taylor, general manager, and has been in operation for two years since track was laid from Page to a connection with the Chesapeake & Ohio R. R. at Deepwater. It consists of a mine with a capacity of 2,000 tons a day and 505 coke ovens producing about 600 tons of coke per 24 hr.

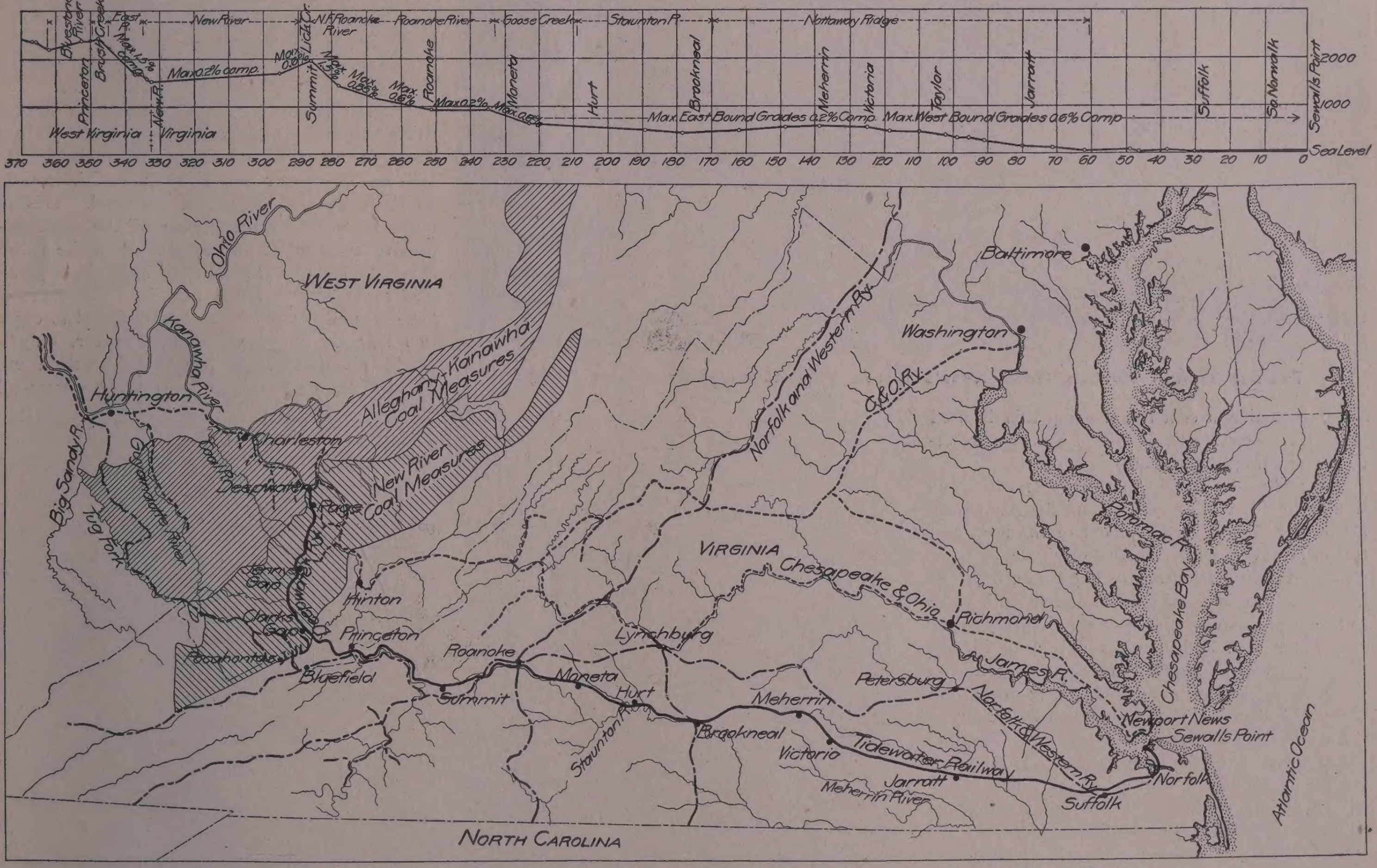
The coal is taken from what is known as the Ansted seam of the Kanawha measures. This seam is 5 to 9 ft. thick and at this development it is 1,700 ft. above sea level and 650 ft. above a tipple with which cars are loaded on a spur track from the main line of the Deepwater Ry. The coal is mined by drifting into the side of the mountain and is worked in the seam by the room system. The mined coal is hauled to the mouth of the drift in 2½-ton cars drawn by mules. The mouth of the drift is 3 miles from the tipple at the railroad siding. Trains of 45 cars are hauled by 25-ton locomotives from the mine down a 1 per cent. grade to a tipple on the side of the mountain 400 ft. above the railroad tipple. This upper tipple is equipped with a Phillips cross-over dump by which the coal is automatically discharged from the cars into either side of a double 100-ton bin. A double-track tramway on grades of from 15 to 25 per cent. leads from the receiving bin to the railroad tipple below. On each track of this tramway is operated a four-wheel truck having firmly mounted on it a steel cylinder, 6 ft. in diameter and with a capacity of 10 tons of coal. A cable is attached to both of these trucks and wound around a drum in the upper tipple so that the trucks are counter-balanced and the loaded cylinder in descending to the lower tipple pulls the empty cylinder up the incline.

The coal is dumped from these cylinders into a pocket built over the railroad siding. It passes over a grizzly at the lower end of this pocket which permits the fine coal to fall through into a pocket below and causes the larger coal to be passed to a pocket beyond. Under normal operating conditions, the large coal is loaded into cars and shipped, while the fine coal is crushed and used for making coke. The tipple is so arranged, however, that run of mine coal may be loaded into cars and shipped. It is also possible to crush the lump coal and divert it back into the pocket containing fine coal in case a sufficient amount of the latter is not available.

The screenings are carried by worm conveyors from the fine pocket below the grizzly to two disintegrators in a house nearby. Each of these disintegrators has a capacity of 100 tons an hour and in them the coal is ground about as fine as corn meal. Two Link Belt flight conveyors, one for each disintegrator, carry the disintegrated coal from the latter about 150 ft. to elevated storage pockets.

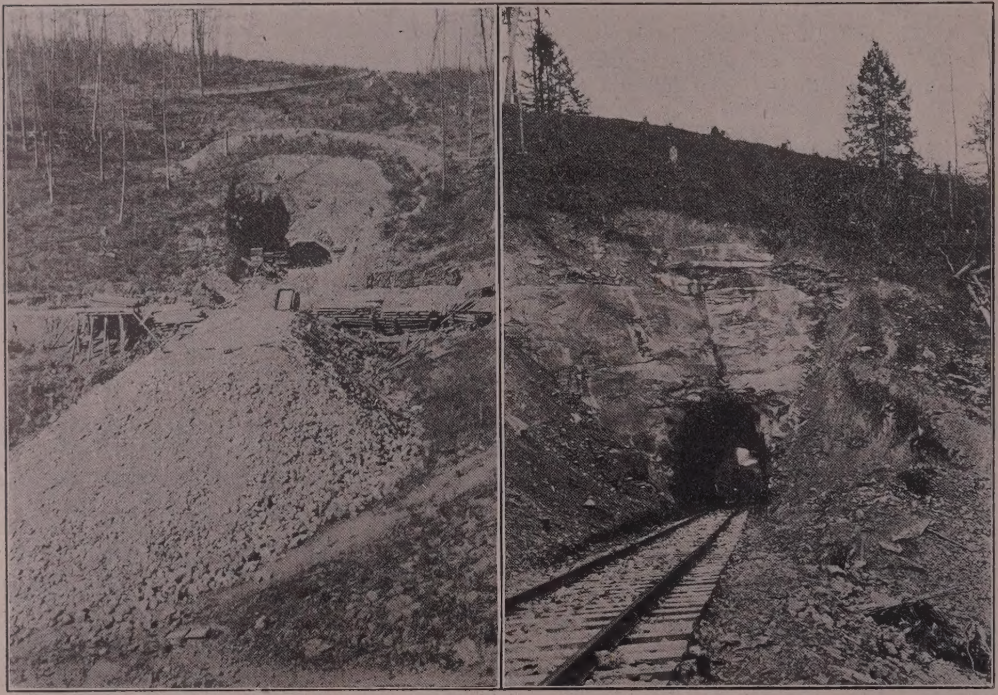
Beyond these elevated storage pockets and farther down the side of the hill are the coke ovens. The ovens are arranged in rows, two rows together back to back in a pair. The pairs are sufficiently far apart to provide room for a firing stage about 14 ft. wide on each side of them, with a standard-gauge track between each pair of adjacent stages. The ovens are each charged through a manhole in the top. Tracks are laid under the elevated storage pockets, which are at about the level of the tops of the ovens. These tracks extend to and along the tops of the pairs of rows, one track down the center of each row. The disintegrated coal is hauled from the storage bins to the ovens in small electrically-driven cars supplied with power from an overhead trolley. These cars are operated in trains of four, one motor and three trailers, and have a maximum haul of about 1,700 ft. The downspouts from the storage pockets are so arranged that four cars may be loaded simultaneously and the manholes through which the ovens are charged are spaced so four of them may be charged from the cars at the same time. The stages along both sides of each pair of rows of ovens are far enough below doors in the sides of the ovens to facilitate the drawing of the coke out on them from the oven through these doors. The standard-gauge track between each two adjacent stages is depressed sufficiently so the tops of coke cars are flush with the stages and coke may be loaded readily into the cars.

The plant is operated from a central power sta-



Map and Profile of the Tidewater and Deepwater Railways and Location of Coal Measures.

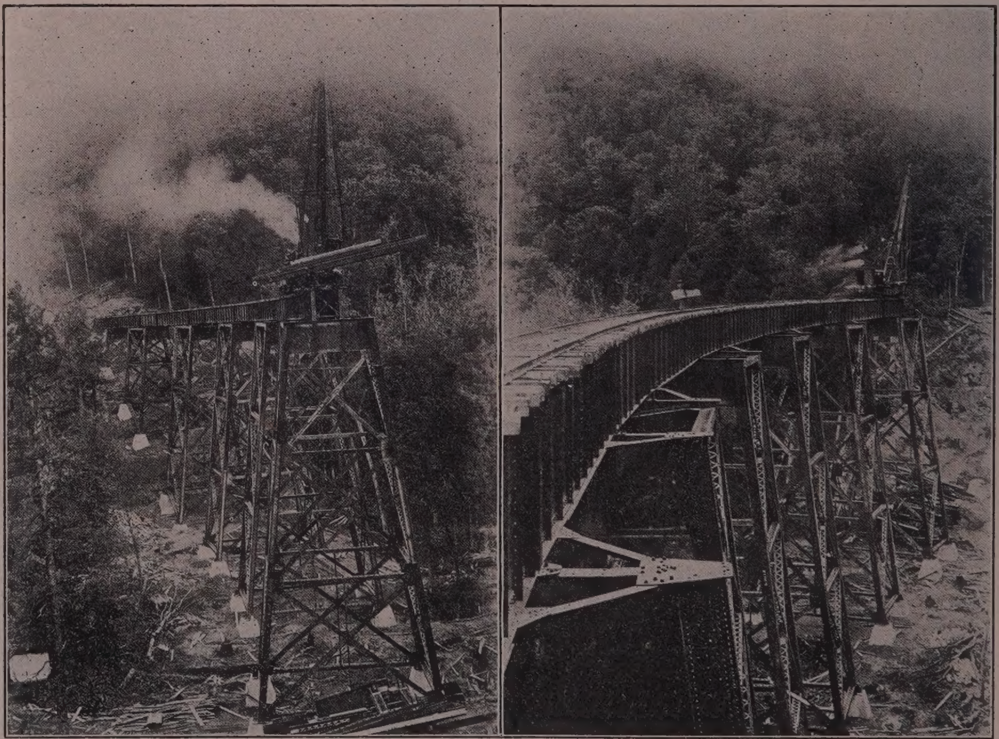
tion containing a 500-h.-p. Nordberg Corliss engine. This engine is supplied with power by four 150-h.-p. Erie City tubular boilers and drives all the crushers, the disintegrators and the belt conveyor from a line shaft. It also drives a 75-kw. direct-current General Electric generator which furnishes power to operate the electric trains. This generator also furnishes power to drive a motor operating a centrifugal pump that is used when the water supply is low in a gravity reservoir containing 325,000 gal.


Typical Tunnel Portals Near Kate's Creek Viaduct and Guyandotte River.

It is practically certain that many developments similar to this will be made along the line of the Deepwater Ry. A large amount of the total coal traffic, however, will doubtless originate in small mines producing from one to five cars a day. At least 1,000,000 acres of land underlaid with three to five seams of workable coal are tributary to the Deepwater Ry., and may be developed in this manner. A large number of seams also exist in these tracts below the ground-water level, but these will also doubtless be worked eventually.

Location and Construction.—From this development, the track of the Deepwater Ry. is on an almost continuous rise for nearly 12 miles to the Silver Gap summit. Just before reaching the summit at Silver Gap the line cuts across the headwaters of a number of small streams and some heavy construction work was involved in building it, included in which are several high wooden trestles that are to be filled in as soon as feasible. Beyond Silver Gap the line drops away to the south for 5 miles until it joins the valley of the headwaters of Paint Creek, another tributary of the Great Kanawha River. It follows up this creek to a second summit at Harper, which is the watershed between streams flowing north and those flowing west, and thence follows generally down Miller's Camp Branch and Surveyor Fork of Coal River until it reaches the headwaters of Slab Fork of the Guyandotte River, which fork it parallels for 12 miles to its junction with the river. A tunnel 800 ft. long was driven through a pass in the mountains called Jenny's Gap in passing from Surveyor Fork to Slab Fork. This pass is the lowest point in the surrounding country and is practically the only way to reach the coal fields from the north on reasonable grades lying south of the ridge in which this pass occurs.

In passing down Slab Fork a number of heavy fills and rock cuts have been made and three tunnels have been driven to keep to a minimum grade or to avoid sharp bends in the stream. The line then follows closely along the Guyandotte River for three miles to the mouth of Barker Creek, a tributary to that stream. In this distance the mountains are close to the stream on both sides, as is characteristic of all streams in that locality, and although they rise somewhat abruptly from the edge of the water, it is possible to make bench cuts along them well above high water to carry the tracks. The Guyandotte River valley and the valleys of streams tributary to it form the richest undeveloped coal fields in West Virginia, being largely New River and Pocahontas coals. A branch line has already been located for 50 miles up the Guyandotte River and its branches, and a second line has been located down the Guyandotte River for 50 miles. This latter line could readily be extended down to the Ohio River on a water grade. Another route feasible for a line to the Ohio River on water grades would be to turn off the present line at Surveyor Creek and follow down the Marsh Fork of Coal River to the latter and thence down that stream to the Ohio River. One of these lines will be constructed when justified and then that portion of the Deepwater Ry. north of the mouth of Barker Creek, or that portion of it north of Surveyor Creek, will be a branch line over which short trains can be operated without difficulty.


Views of Bridge 65 during Erection.

A long narrow assembling yard is to be constructed on a bench cut in the hillsides along the 3 miles where the tracks parallel the Guyandotte River from the mouth of Slab Fork to the mouth of Barker Creek. The center of the coal developments whose production will be tributary to the Deepwater Ry. will doubtless be near the mouth of Barker Creek for many years and the coal originating from these developments will be brought together in this yard. The main line crossing the headwaters of various streams as it does, both to the north and to the south of this yard, and being located on a broad table-land, will permit the construction of branches leading from it up these streams at water grades.

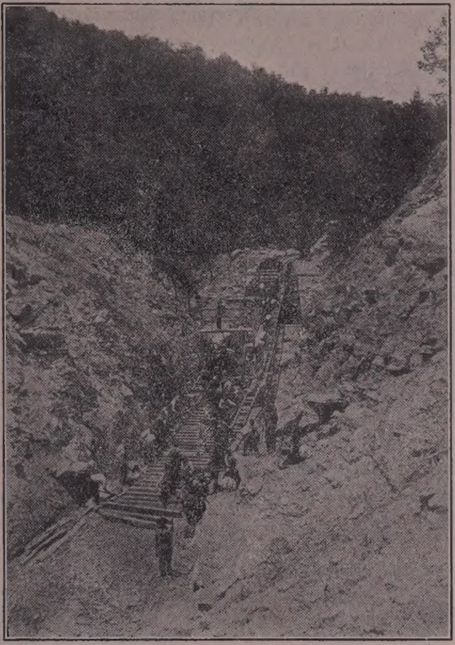
South from this yard the line follows Barker Creek and then a branch of it called Gooney Otter Creek for 10 miles and rises to the highest point between Deepwater and Norfolk at Clark's Gap, which is 2,500 ft. above the sea level. This 10 miles of work required some of the most expensive construction of any portion of the entire line. It includes eight long, high deck plate-girder viaducts and five tunnels. The viaducts have all been built with towers designed to carry two tracks. For the present, however, only a single pair of girders will be placed on them and a single track laid. The legs of the towers all rest on concrete pedestals and their end spans on concrete abutments.

The first of the viaducts, known as bridge 60, has a maximum height of 50 ft. and is 363 ft. long. It is built over Barker Creek and has a span of 31 ft. 7 in. at each end, with 30-ft. towers and 60-ft. spans throughout the remainder of its length, and is on a 12 deg. curve. The second one of these viaducts, bridge 61, is 422 ft. 8 in. long and has a maximum height of about 50 ft. It also has 30-ft. towers and 60-ft. spans, with a

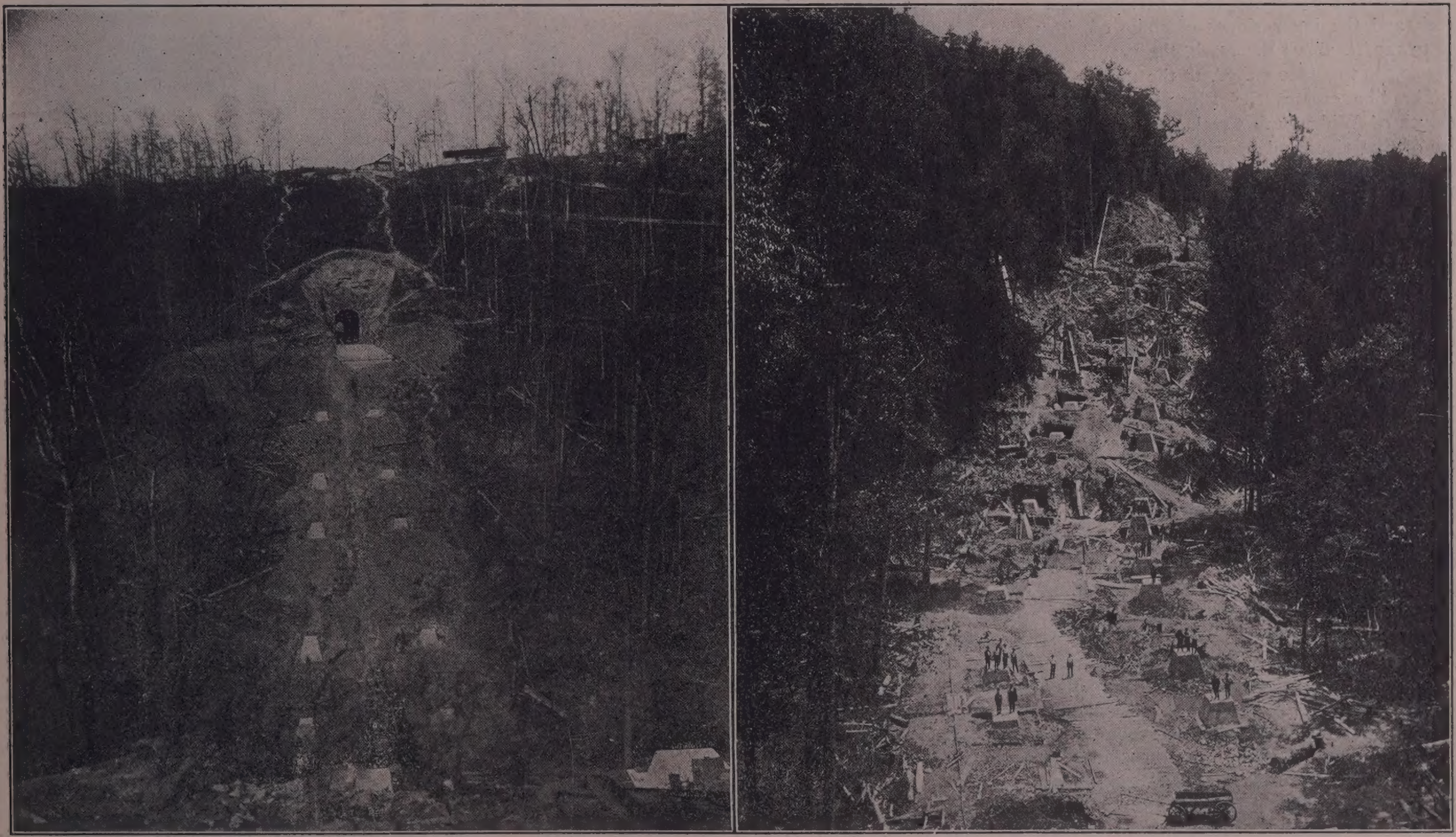
61-ft. 4-in. span at each end, and is over Barker Creek. The next viaduct of any size is bridge 64 over Gooney Otter Creek. This structure is 342 ft. 9 in. long and 40 ft. high, with a 41-ft. 3-in. span at one end and a 61-ft. 7-in. span at the other end, and the usual 30-ft. towers and 60-ft. spans.

The next viaduct in succession, bridge 65, has a maximum height of 110 ft., is 732 ft. long and also spans the valley of Gooney Otter Creek. It has 30-ft. towers and 60-ft. spans and is partly on tangent and the remainder on a 7 deg. curve. Less than a mile beyond this viaduct is another viaduct over Gooney Otter, bridge 66, that has a maximum height of 165 ft. and is 714 ft. long. The pair of girders for one track only have been placed on this structure.

From the yard at the mouth of Barker Creek to a point just beyond the viaduct last mentioned, the grading work is not heavy as compared with some other work in the immediate vicinity, but in order to secure a uniform grade required a number of large individual cuts in rock, including 111,000 cu. yd. of sidehill grading in one mile and fills of considerable amounts to secure a uniform grade. Within two miles from this last bridge, three tunnels had to be driven. The first two of these are in the same mile and are 347 and 405 ft. long, respectively. Between the second and third, a viaduct was first planned over a deep, narrow gully, but this has been replaced by a fill 125 ft. high that will contain about 140,000 cu. yd. of rock. A large part of this material has been obtained from the two tunnels on one side and the one tunnel on the other side of it.



Track Laying Machine in Operation.



Views Showing Typical Occurrence of a Tunnel and Viaduct Together and Pedestals in Place for a High Viaduct.

The headings for the first two tunnels were both driven partly from both ends, while the benches of both were taken out from the end next to the big fill and the material used in the latter. Both the heading and the bench of the third tunnel, which is 1,255 ft. long, were taken out from the end next to the big fill. The material from a heavy approach cut on the opposite end of the third tunnel was also largely utilized in the fill.

An Ingersoll-Sergeant air compressor, with a capacity of eight drills, or about 1,000 cu. ft. of free air a minute, was set up 3,000 ft. from the distant end of the third tunnel at a point where a water supply was convenient. This compressor operated at 70 to 80 lb. pressure and air was carried from it to the third tunnel in a 3½-in. pipe line. This line was then reduced to 1¼-in. and extended to the other two tunnels, the total length of pipe line being 1½ miles. The material was handled from these tunnels to the dump in cars drawn by mules or in carts, as the haul was short.

A little more than one-half mile beyond the last of these three tunnels the line passes through a pass known as Micajah's Gap, in a spur of the mountains that are a part of the Great Flat Top Mountain, and three miles beyond this pass through a second pass, known as Clark's Gap, through the main chain of these mountains. These two passes are the only feasible outlets from this section of the coal fields and their occupation is a particularly strategic one. Between them two tunnels have been driven and three large viaducts are required.

The first tunnel is 450 ft. long, and has 250 ft. of cover. The second is 1,205 ft. long and is on the summit of Clark's Gap. The headings of this tunnel were driven from both portals. A Rand air compressor, with a capacity of operating eight drills, was set up at one portal and air piped from it to both headings. The tunnel was driven through hard rock with the exception of a 52-in. vein of coal that was encountered throughout its entire length.

The first of the three viaducts between these two passes, bridge 68, is 380 ft. long and has a maximum height of 90 ft. above low water. It has 30-ft. towers and 60-ft. spans, with a 30-ft. span at one end and one of 50-ft. at the other end. The second of the three, bridge 69, has a total length of 540 ft., is 140 ft. high, and is on an 8 deg. curve. It has the regular 30-ft. towers and 60-ft. spans, with a 30-ft. span at each end. The third viaduct, bridge 70, has a total length of 480 ft. and a maximum height of 135 ft., with the regular 30-ft. towers and 60-ft. spans and a 45-ft. span at each end.

The line follows the valley of Widemouth Creek practically from Clark's Gap to the Bluestone River, a distance of 10 miles. From Barker Creek on the opposite side of Clark's Gap to the point where the line reaches the Bluestone River the country is exceedingly rough and broken, seemingly impossible for the construction of a railroad with grades over which traffic could be operated. The line has been built to Clark's Gap, however, without unjustified expense, as may be drawn from the foregoing description and considering the country, with remarkably good alignment. Beyond Clark's Gap for 5 miles the work is comparatively light, averaging 60,000 to 75,000 cu. yd. of grading to the mile, most of which is, of course, in solid rock. From a point about three miles from Clark's Gap to the Bluestone River, a branch of the Norfolk & Western R. R. is built up the valley of Widemouth Creek. The line of the Deepwater Ry., therefore, had to be built to suit the prior location.

Inasmuch as no grade crossing of railroads outside of cities is included in the entire line of both the Deepwater and Tidewater Rys., with two exceptions, and as the valley of Widemouth Creek is narrow and tortuous in places, seven crossings of this branch line are made in 5 miles. At each of these crossings a stream crossing is also generally included. Aside from these crossings, the work is largely short, heavy cuts through points of rock to keep as straight an alignment as possible where the creek makes sharp turns. Three miles before reaching the Bluestone River the creek makes a long turn to one side from its general direction, which the railroad avoided by driving a tunnel 580 ft. long. The creek is close on each side to the foot of the hill through which the tunnel has been driven and a creek crossing is close to both portals. For about a mile and a half on each side of this tunnel a number of heavy sidehill cuts had to be made where the mountains rise abruptly from the bed of the creek. These cuts are for the most part through solid rock and the inner slopes of some of them rise 80 to 120 ft. above the track, the grading averaging 60,000 to 75,000 cu. yd. to the mile.

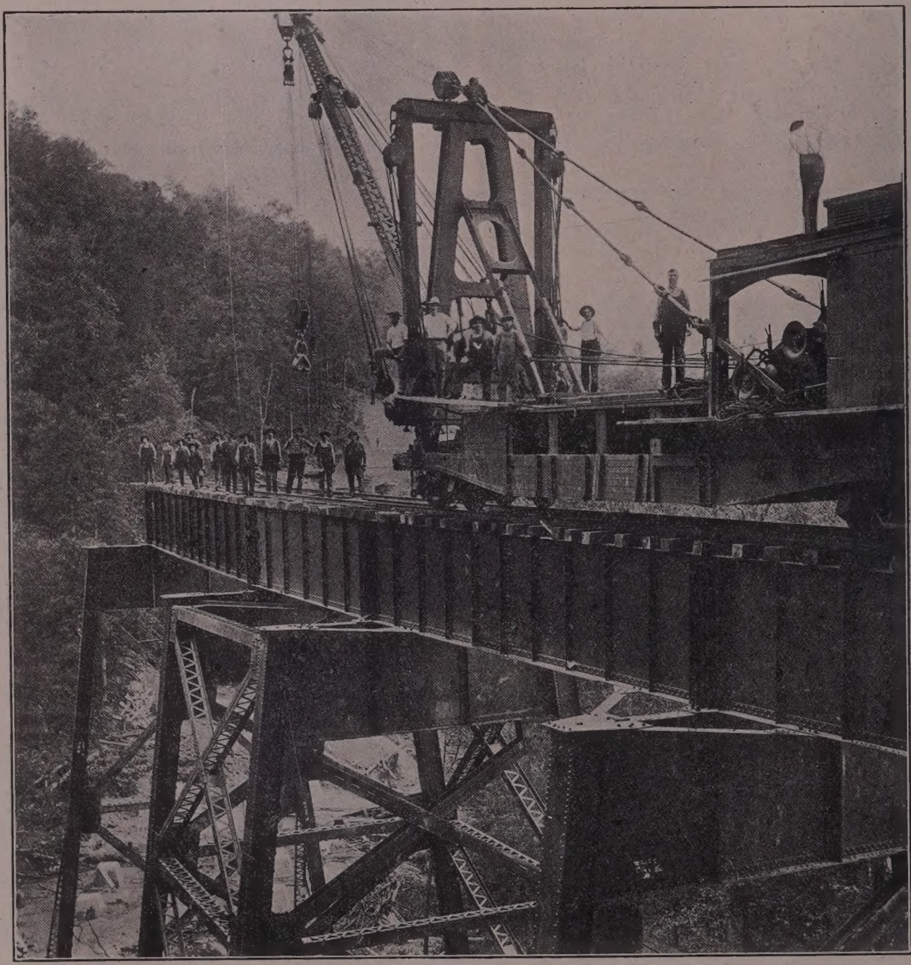
The line crosses the Bluestone River at the mouth of Widemouth Creek and follows the valley of that river and its tributaries for 11 miles to a large collecting and sorting yard at Princeton. In this 11 miles the line rises continually on a 0.5 per cent. compensated grade. Although the country is hardly so broken for this distance as it is in the vicinity of Clark's Gap, there are few continuous mountains or hills and it is remarkable how well the 0.5 per cent. grade fitted the topography. At several points divides occur through spurs of mountains in just the right place, while in a few instances some heavy grading was necessitated and between the Bluestone River crossing and Princeton a very high viaduct and two tunnels were required.

In the first 8 miles from the Bluestone River crossing the line is 150 to 200 ft. above the bottom of the valley of that river and the valley of one of its tributaries, Black Lick Creek, following generally along the hillsides. The grading consists in cutting through the ridges which run out into the valley or in breaking across country where the streams are crooked. Just east of the river crossing a heavy approach fill to the latter is being made with material that is taken out of a 65,000-yd. rock cut in the next mile by a 70-ton Bucyrus steam shovel. The two tunnels occur in the next mile beyond this cut, and are 525 and 435 ft. long, respectively. Between these tunnels and on either side of them, numerous cuts are made in the solid rock hills, the work being handled with carts or cars, as the haul is short to the fills across deep narrow gulches in which the material is practically all utilized. In the third and fourth miles from the river crossing the grading runs 96,000 and 105,000 cu. yd. to the mile, respectively, mostly in solid rock. A 70-ton Atlantic steam shovel is at work in a 75,000 cu. yd. rock cut in the fourth mile. This cut is all being hauled out to the west in narrow-gauge trains by locomotives to make a long, high fill across a wide valley.

A 70,000-yd. cut, partly in rock, is being made in the fifth mile from the river crossing by a 30-ton traction steam shovel built by the Ohio Steam Shovel Co. This shovel is working in connection with four wheel 2-yd. dump wagons, which have a haul of about 1,500 ft. It was brought into the work under its own steam, and although light, has given satisfactory results.

The line cuts across to the oposite side of the Black Lick Creek valley, about a mile beyond this last steam shovel cut, and in making this crossing a viaduct 904 ft. long and with a maximum height of 188 ft. is required. This viaduct has a 57-ft. 8-in. span at one end, then two 30-ft. towers and two 60-ft. spans, then four 40-ft. towers with 80-ft. spans between them and at the opposite end two 60-ft. spans and two 30-ft. towers, with a 45 and a 42½-ft. span having a single bent at the end. This viaduct is one of the highest bridge structures on either of the railroads.

The line follows the side of the valley of the creek for the next mile and then cuts across country to a divide known as Low Gap, which is two miles from the viaduct. In these two miles the hills are short and steep as they break into the valley and the line cuts through the tops of them. In all 170,000 cu. yd. of grading, mostly in solid rock, has to be done, and one tunnel, 405 ft. long, driven in between the viaduct and the divide.



Special Derrick Car used in Erecting High Viaducts.

An electrically-operated shovel, somewhat similar to an ordinary steam shovel, has been installed in a cut in the second mile. This machine consists of two carriages, one mounted on a four-wheel truck running on rails and a second one mounted on the lower one. The upper carriage revolves on the lower one and carries a steel mast and a boom or bucket arm. The mast is guyed at the top with four cables, one in each of four directions, the cables passing over pulleys in the top of the mast and being wound on small drums under the carriage, which arrangement permits the guys to be slackened or tightened as required. The dipper is manipulated in about the same way a steam shovel dipper is operated. The entire machine is driven by a 30-h.p. Bullock motor, which is geared to a line shaft. The various movements of the bucket and upper carriage are controlled by levers mounted on that carriage, which levers operate friction clutches mounted on this line shaft. Power is transmitted to the shovel from a central generating station about a mile distant, installed for the purpose.

Leaving Low Gap the line turns into the valley of Brush Creek, up which it continues for 3.5 miles to a pass through a second summit at Oney Gap. Low Gap is a controlling point in the line which secures a crossing through a high and nearly continuous ridge of mountains. The line passes through it in a small cut, however, and reaches the broadest and flattest valley that is met in the 95 miles from Deepwater to this point. In this valley the grade is level for two miles to the point where the rise to the Oney Gap summit is started, and it is in these two miles that the Princeton yard is to be constructed.

Location of Assembling Yard.—This yard bears the same relation to the coal traffic on the Deepwater and Tidewater Rys. that the yard at Hinton, W. Va., on the Chesapeake & Ohio R. R., the yard at Bluefield, W. Va., on the Norfolk & Western R. R. and possibly the yard at Grafton, W. Va., on the Baltimore & Ohio R. R., bear to eastbound coal traffic over those roads from the West Virginia fields. As has already been explained in the case of the first two railroads just mentioned, a large amount of their coal traffic originates on branches having more or less steep grades. Many of these branches contribute only a few cars a day and over some of them the operation of long trains is not feasible. The short trains, resulting from these two causes, are brought into assembling yards, located as stated, and from these yards long trains are made up and sent through to tidewater, or to connecting lines to which coal traffic is diverted. One of the controlling elements governing the economical operation of a coal carrying road is the possibility of making up long trains in these assembling yards which may be continued through to their destination without a break; that is to say, the elimination of occasional grades considerably heavier than the average maximum grade. At the same time, to permit economical operation between this yard and the destination of traffic, it is essential that the grades against traffic shall as nearly as possible balance those against returning trains of mostly empty cars. In other words, a locomotive which can haul a certain number of loaded cars in the direction of traffic should be able to return with a train that will practically require its entire tractive effort on the average maximum grade.

Grades from Princeton to Norfolk.—These conditions are almost ideally met in the grades that have been secured on the 350 miles of the Deepwater and Tidewater Rys. between the Princeton yard and tidewater at Norfolk. The maximum grade against eastbound traffice in this entire distance is, with two exceptions, 0.2 per cent., compensated, while the maximum grades against westbound traffic is, with two exceptions, 0.6 per cent., compensated. The first of the exceptions to the 0.2 per cent. compensated grade against eastbound traffic is the rise from Princeton yard to the summit at Oney Gap, where for two miles the line has a 0.6 per cent. compensated grade. The first of the exceptions to the 0.6 per cent. compensated grade against westbound traffic is on the opposite side of this summit, where for nine miles the line rises on a 1.5 per cent. compensated grade. The second exception to both ruling grades against eastbound and westbound traffic occurs at the summit of the Allegheny Mountains, which is 60 miles east of Oney Gap summit. In order to get over the Allegheny summit the grade rises for 9 miles against eastbound traffic with a maximum of 0.6 per cent. compensated; on the opposite side of the summit the grade against westbound traffic rises with a maximum of 1.5 per cent., compensated, for 8 miles.

With the grades that have been secured a single engine of the type that is to be installed can haul eighty loaded 100,000 lb. capacity cars from Princeton yard to tidewater without assistance, except at the summits that have been mentioned. The same engine can haul an equal number of empty cars against westbound grades without assistance, except at the two places noted. At the two summits, only a single helper engine will be required in either direction, and the proximity of the pusher grade in the opposite direction will render this helper service most economical.

(To be continued.)

Portal of Tunnel under Construction near Bridge 64,

Effect of Duration of Stress on Strength and Stiffness of Wood.

It has been established that a wooden beam, which for a short period will sustain safely a certain load, may break eventually if the load remains. For instance, wooden beams have been known to break after fifteen months under a constant load of but 60 per cent. of that required to break them in an ordinary short test. There is but little definite and systematic knowledge of the influence of the time element on the behavior of wood under stress. This relation of the duration of stress to the strength and stiffness of wood is now being studied by the Forest Service at its timber-testing stations at Yale and Purdue Universities. The investigation should determine: the effect of a constant load on strength; the effect of impact load or sudden shock; the effect of different speeds of the testing machine used in the ordinary tests of timber under gradually increasing load; and the effect of long-continued vibration.

To determine the effect of constant load on the strength of wood a special apparatus has been devised by which tests on a series of five beams may be carried on simultaneously. These beams are 2x2 in. in section and 36 in. in length, each under a different load. Their deflections and breaking points are automatically recorded upon a drum, which requires 30 days for one rotation. The results of these tests, extending over long periods of time, may be compared with those on ordinary testing machines, and in this way safe constants, or "dead" loads, for certain timbers, may be determined as to breaking strength or limited deflections.

The experiments of the Forest Service show that the effects of impact and gradually applied loads are different, provided that the stress applied by either method is within the elastic limit of the piece under test. For example, a stick will bend twice as far without showing loss of elasticity under impact, or when the load is applied by a blow, as it will under the gradually increasing pressure ordinarily used in testing. These experiments are being extended to determine the general relations between strength under impact and gradual loads.

Bending and compression tests to determine the effect of the speed of application of load on the strength and stiffness of wood have already been made at the Yale laboratory. The bending tests were made at speeds of deflection varying from 2.3 in. per minute to 0.0045, and required from twenty seconds to six hours for each test. The woods used were longleaf pine, red spruce, and chestnut, both soaked and kiln-dried. From the results are obtained comparable records for difference in speeds in application of load. A multiplication of the results of any test at any speed by the proper reduction factor, derived from these experiments, will give equivalent values at standard speed. The tests also show concretely the variation of strength due to variations of speed liable to occur during the test itself. The results plotted on cross-section paper give a remarkably even curve as an expression of the relation of strength to speed of application of load, and show much greater strength at the higher speeds. A numerical expression of the law, averaging all species, both wet and kiln-dry, gives the following table, which shows the increase in strength with the increase of speed of test:

Minutes to move crosshead one inch	Ratios of ultimate strength Compression	Bending
900	100	100
350	100.8	100.9
150	102.3	107.3
40	106.9	110.1
5	113.8	118.7

The first column, which gives the number of minutes required to move the crosshead of the testing machine over the space of one inch, is the reciprocal of speed. The second and third columns give the effect of this increase of speed upon compression and bending, respectively, and show that strength increases with speed. The strength at the lowest speed is arbitrarily fixed at 100 as a convenient basis for comparison. The ordinary bending-test speed for small specimens is one-tenth inch per minute, or, reciprocally, 10 minutes are required to move the crosshead one inch.

It is common belief among polemen that the continual vibrations, to which telephone poles are subjected, take the life out of the wood and render it brash and weak. Nothing is definitely known as to the truth or falsity of this idea. Tests will be undertaken to determine the effect of constant vibration on the strength of wood.

Experiments with Tar Macadam have been made on a 300-ft. stretch of the Victoria Embankment roadway, London. This length was divided into three equal sections. Mountain limestone, 2-in. granite and blast-furnace slag formed the body of the three pavements. The portions laid with limestone and slag were completed in good weather, but rain interfered with work on the granite section. The tar did not seem to soak into the granite at all, but both the limestone and slag were to a certain extent impregnated with it. Within a month the granite section showed signs of breaking up, probably attributable to the wet weather when it was put down. It was repaired, but soon gave way again. The limestone also showed signs of giving way in about three months, and Mr. M. Fitzmaurice, engineer to the London City Council, whose notes on these experiments were recently published by the Institution of Civil Engineers, decided to take up both limestone and granite. The slag macadam was allowed to remain, but apparently was not very satisfactory, since Mr. Fitzmaurice says that the results of the experiment do not indicate that tar macadam is suitable for heavy, fast traffic such as occurs on the Victoria Embankment. In each case the sample pavement was about 700 sq. yd. in area and 6 in. thick. The contract prices for material and laying, per square yard, were, limestone and slag, about $1.10, and granite, about $1.28.

The Freezing Process in the Battery Tunnel, New York.

The two parallel cast-iron lined tubes of the New York Rapid Transit Railroad Commission's tunnel under the East River, from the Battery to Brooklyn, have been driven through soft material by hydraulic shields of improved construction. In some places the movement of the shields, aided perhaps by settlement and undermining, caused deviations in the alignment of the tunnel from its required position. Although these divergencies were not great enough to be serious otherwise, they were in some instances sufficient to interfere with the required grade, and in order to rectify the latter, it was necessary to depress certain portions of the invert and raise parts of the crown in order to provide clearance for the trains.

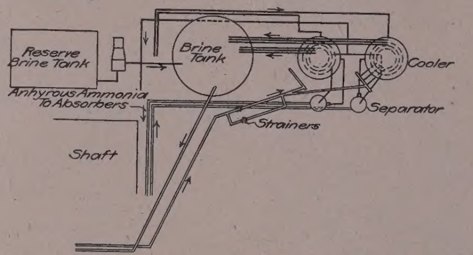
These changes, although simple in their nature, involve considerable difficulty on account of the heavy external pressure, the character of the soil and presence of water in it. They extend over a total length of about 2,500 ft. in the east approach to the river, and have been carried on by three radically different methods of operation. The first, which was described in The Engineering Record of June 2, was done under atmospheric pressure, and consisted in the replacement of the lower sections of the lining with a reinforced concrete invert and side walls supporting the roof on special cast-iron skewbacks. The second method, described on Sept. 20, consisted in putting short sections of the tubes under pneumatic pressure, supporting the roof temporarily by timbering, as was done in the first method, and finally replacing the lower sections of the lining one at a time by special new cast-iron segments similar to the old ones, but having their dimensions changed so as to increase the vertical diameter of the tube to the required amount. Both of these methods were at first used only where it was necessary to depress the tunnel invert.

The third method was planned to be used in the cases where alterations were required necessitating the removal of the upper segments of the lining. It was anticipated that this work would be much more difficult than the other, and although none of it was finally executed by the plan proposed, the details of that plan were carefully developed, the necessary plant installed and operations carried far enough to demonstrate the principal features of the method in a very interesting manner, which is the more notable since the system is one that has been very rarely applied to tunnel work.

Where the grade of the tunnel dropped below the proper alignment so much that the train clearance between the corrected grade and the upper part of the lining was eliminated, the problem of the construction became serious on account of the difficulty of holding up the earth when the crown segments were removed. As the material encountered here was known to be entirely of sand varying from coarse to fine and to quicksand, it was anticipated that great difficulty would be encountered. It was thought that it could be best overcome by freezing the wet material on all sides of the tunnel tubes until a protecting cylinder had been formed around them thick and strong enough to exclude water and quicksand and to resist external pressure long enough to permit the removal of the old tunnel shell and the rebuilding of modified sections of it.

A refrigerating plant was therefore installed and was successfully operated for several weeks on the cold-air circulation principle, which in a short time reduced the temperature in the tunnel to a low degree and froze the materials outside to a considerable depth. Two 25-ton absorption refrigerating machines of the Carbondale type were installed in a small house built for the purpose at one end of the New York Tunnel Co.'s power house at Joralemon and Furman Sts., Brooklyn. These were connected with brine coolers near the north shaft, and from this point the brine was circulated down the shaft and for a distance of about 1,000 ft. in the tunnel to a section 272 ft. long enclosed by insulating bulkheads, built with double thicknesses of wood 10 in. apart, filled between with mill shavings. Here a special apparatus was introduced by means of which the cooling of air in the tunnel to a low temperature was effected, and the brine was returned to the refrigerating machines. Two systems of circulation were thus constantly maintained, one of the brine from the refrigerating machine to the tunnel and the other of the air in the closed tunnel section which was constantly passed through the refrigerating apparatus. In this manner the entire system was operated under a closed circuit, and the heat in the tunnel and adjacent to it was absorbed and finally discharged in the water used for cooling purposes in the refrigerating apparatus.

Very few attempts have been made to apply the freezing process to tunnel construction. One of the earliest, at Stockholm, was described in The Engineering Record of May 6, 1886. Here the air was cooled by expansion and the work was done slowly and under great expense. Experimental work is now in progress for the Pennsylvania R. R. Co., in a heading under the North River, where brine is circulated through pipes. The work here described is the first in which air cooled by the absorption process has been used for the freezing. The apparatus employed is of the standard absorption type, but is novel in the details of the method by which the cold brine is made to absorb the heat of the air and on account of the unusual large distance between the refrigerating machinery and the brine coolers. The absorption type of refrigerating machinery was selected here on account of its adaptation to low temperature contracting work, its essential requirement, outside of the compact plant, being merely an abundance of cold water for cooling purposes.



Brine Coolers at Top of Shaft.

Two 25-ton absorption refrigerating machines of the Carbondale type were assembled by the New York Tunnel Co., who in order to install them more quickly than they could be delivered by the regular manufacturers, combined such portions as could be found in stock at Carbondale with condensers built by the York Manufacturing Co., fittings from Crane & Co., and other items wherever they could be secured, thus building machines that, although characterized by the constructor as "things of shreds and patches," were very quickly secured and proved efficient. They were installed in two stories of the refrigerator house, as indicated in the accompanying diagram. Most of the units in the plant were made double, so that, although it was not designed as a duplicate system, almost any portion of the apparatus could be cut out for fitting or repairs, while the twin members continued in operation and maintained the refrigeration without cessation, although at a reduced speed.

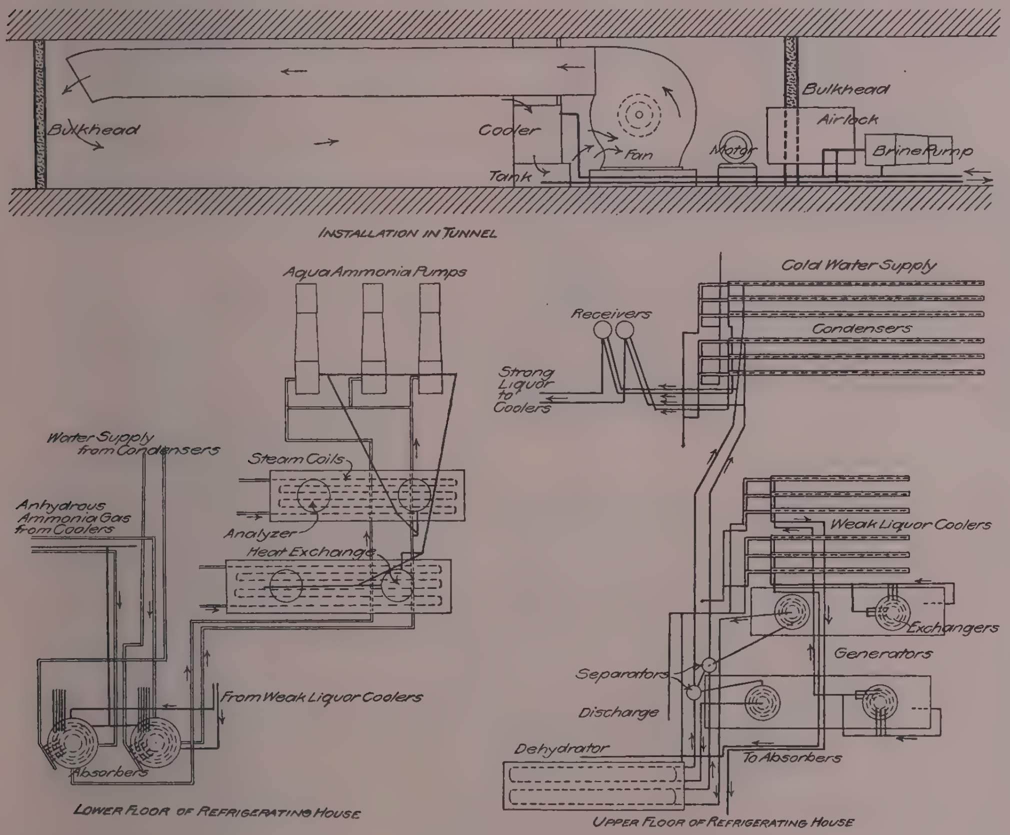
The operation was substantially as follows: Aqua ammonia (a solution of about 30 per cent. of ammonia in 70 per cent. of water) was constantly delivered by three Guild & Garrison 8x4x10-in. pumps in the first story of the refrigerator house to the analyzer, a vertical cylinder containing a series of shallow horizontal trays over which the liquid flowed in thin sheets and was partly warmed by the upward current of ammonia gas from the still below. From the analyzer the aqua ammonia passed down to the still, which was a horizontal cylinder containing steam coils. Here part of the ammonia was boiled out of the liquid and it was reduced to an 18 per cent. solution, termed weak liquor. The liberated gas rising from the still passed back through the analyzer, where it was partly dehydrated and served, as already mentioned, to warm the incoming liquor. From the analyzer, the gas passed into the dehydrator in the upper story of the refrigerator house. In the dehydrator it passed through a pipe coil immersed in a tank of water which cooled it to a temperature of about 125° and under the pressure of 120 lb. produced in the still, it was delivered from the dehydrator in practically anhydrous condition to the condensers, the steam heavily charged with ammonia gas having been trapped out and dropped back to the bottom of the analyzer. In the condensers the dry gas was liquefied by cold water circulating around the pipes in which it was contained. From the condensers the liquid ammonia flowed, still under the same pressure of 120 lb., to a pair of receiver tanks about 10 in. in diameter and 5 ft. high. These tanks were provided with gauge glasses and served only to equalize irregularities of flow and provide a convenient point for inspecting the liquid. From the receivers the liquid ammonia flowed through a ¾-in. pipe 300 ft. long to the brine coolers, and was delivered through expansion valves to the interior of the cooling tanks which contained brine coils. Here the pressure was reduced to atmospheric, allowing the liquor to boil, and the resulting temperature of — 29.6 F. served to absorb the heat from the brine, thus cooling the latter nearly to that temperature.

From the coolers the anhydrous ammonia gas at atmospheric pressure returned through a 3-in. main carried with the ¾-in. delivery main under the eaves of the power house, to the absorbers located on the lower floor of the refrigerating house. They are steel cylinders 30 in. in diameter and 10 ft. high, containing concentric spiral coils through which water at 70° F. was circulated. The weak liquor (the 18 per cent. solution of aqua ammonia from the bottom of the still) was sprayed in a thin film over the water coils and so absorbed the gas. The heat thus generated by the liquefaction of the latter passing into the coils, while the weak solution was thus restored to its original strength of 30 per cent. Beaumé, the strong aqua ammonia referred to in the commencement of the description. This liquid was pumped from the absorbers to the exchangers over the stills, where it passed through series of spiral coils enclosed in vertical cylinders about 2 ft. in diameter and 5 ft. in height. The weak aqua ammonia passed through these cylinders and around the coils on its way to the absorbers and parted with some of its heat to the cooler strong liquor. From the exchanger the weak aqua ammonia passed through a series of coils in the upper story, which were cooled by water circulation to a temperature of about 75° before it reached the spray in the absorber. Meantime the strong liquor passed from the exchanger to the analyzer and was again used for brine cooling, as ing.

The brine tanks and pipe contained about 1,500 gal. of solution of chloride of calcium of a specific gravity of 1.23 to 1.24 with a freezing point of — 25 to — 30° F. This flowed by gravity from the top of the shaft about 1,000 ft. in the tunnel through a 6-in. pipe to the 6x4x8-ft. air cooler. The cooler was a rectangular steel case containing a series of thin plates of galvanized iron slightly inclined from the vertical and spaced about ½ in.

apart, with a combined area of about 10,000 sq. ft. The cold brine was discharged above them through a series of sprinklers, flowed in thin films over the plates and was collected in a pan below them. The air from the tunnel entered the top of the cooler and passed downwards between the plates, thus coming in contact with the greatly extended surface of the cold plates and having its heat absorbed by the brine. Clearance was left for the air to pass between the cooler and the brine tank to the inlet of a 160-in. American Blower Co.'s fan, driven at 160 r. p. m. by a Westinghouse motor with a Cutler-Hammer speed controller. The fan delivered about 34,000 cu. ft. per minute of air to an overhead duct 5 ft. in diameter with its outlet at the opposite end of the tunnel section.

The duct was made of 6-oz. duck in cylindrical sections 8 ft. long with the ends engaged between concentric pairs of 2x¼-in. steel hoops tightened by a turnbuckle in the outer hoop, binding them so closely together that a perfect joint was secured. The air escaped freely from the end of the duct and, absorbing heat from the tunnel and its lining, returned at a higher temperature to the cooling chamber, where it again passed between the surfacer plates, and so on, through the fan and ducts again, maintaining a constant circulation and continually delivering the heat it absorbed to the brine, which was pumped from the tank to the brine cooler at the rate of about 175 gal. a minute, by a Cameron pump with a capacity of 250 gal. per minute. The brine circulating continuously through the coil in the cooler delivered its heat to the anhydrous ammonia and returned to the tunnel at a temperature varying from —5° to —25° Fahr.



Cooling Plant in Refrigerating House and in Tunnel.

At the beginning of the work water entered the tunnel through numerous leaks, and the air was saturated with moisture, large amounts of which were absorbed by the brine flowing over the surface in the air-cooling chamber. This absorption, of course, weakened the brine, and in order to maintain its efficiency as the volume increased and the strength decreased, a portion of it was pumped into a 1,000-gal. reserve tank where chloride of calcium was added to it and it was restored to the circulation system. This gradually increased the volume of brine and had the operations been continued there would eventually have been an excess of brine and the reserve tank would have been replaced by a concentrator.

About 100 leaks were at first observed in the flanged joints. Most of them were comparatively small and gradually froze up, but one of them with a flow of about 18 gal. per minute was very persistent and special measures were necessary to stop it. It was first enclosed by concrete which blew off as soon as the pressure was developed. In the second attempt the concrete was reinforced and carefully molded to the flanges of the lining to make a box about 14 in. wide, 6 in. long and 8 in. high on the bottom of the tunnel. A pipe was built into the box and allowed the water to escape until the concrete was thoroughly set, when the pipe was plugged and the concrete was found strong enough to withstand the pressure, amounting to about 8 lb. per square inch.

In order to estimate the strength of the frozen material outside of the tunnel, preliminary tests were made, before the freezing process was commenced, on specimens of sand mixed with from 7 to 30 per cent. of water and frozen in the standard molds used for cement briquettes. These were frozen at temperatures of 0°, + 10°, + 20°, and +24° Fahr., and were broken in a cement testing machine. They gave values of from 30 lb. for the 7 per cent. briquette to 460 lb. for the 30 per cent. briquette, at a temperature of + 15°. The 7 per cent. briquettes were very dry, having only about as much water as they would take by capillary attraction. The 30 per cent. briquettes were saturated, and it was assumed that they represented fairly a large proportion of the material adjacent to the tunnel lining, the top of the tunnel being at about ground water level at one end of the section refrigerated and rising about 3 ft. above it at the other end.

At the commencement of operations the temperature of the cast-iron lining and of the arch in the tunnel was 60° Fahr. Brine was delivered to the surfacing plates in the cooling box at a temperature of 1°, returning to the brine cooler at a temperature of 10°. On the fifth day, the corresponding temperatures of the brine were —6° and 0°; on the tenth day —10° and —3°. The temperature gradually decreased until the twentieth day when they were reduced to —16° and —8°, and were so maintained until the termination of the work on the twenty-eighth day. The temperature of the air in the tunnel was reduced to 26° on the fifth day, 12° at the outlet of the circulation duct and 19½° at the inlet of the cooling chamber on the twentieth day, and to 1° and 8° on the twenty-eighth day. Ice commenced to form on the fourth day when the temperature of the plate wos 32.°

During the progress of the freezing, explorations were made beyond the walls of the tunnel by drilling radial holes until the water entered through them. In some cases the 1-in. screw plugs were removed from the grouting holes and ½-in. holes were drilled concentric with them by a hand brace drill. In other cases 4-in. circles were cut out of the lining plates by small ratcheted-holes, some of the sand was excavated through them and the small holes drilled as before. After one or two holes had been drilled through to water, the succeeding holes were stopped a little short of this point and slow-reading thermometers were placed in them and the holes filled up with dry sand from the outside. The thermometers were allowed to remain one day in the hole, and after they were removed the holes were extended until the water entered through them. The sand provided by the 4-in. excavations and by the drills was carefully examined and compared with the test briquettes, thus providing a basis of estimate for the strength of the frozen ring outside the tunnel.

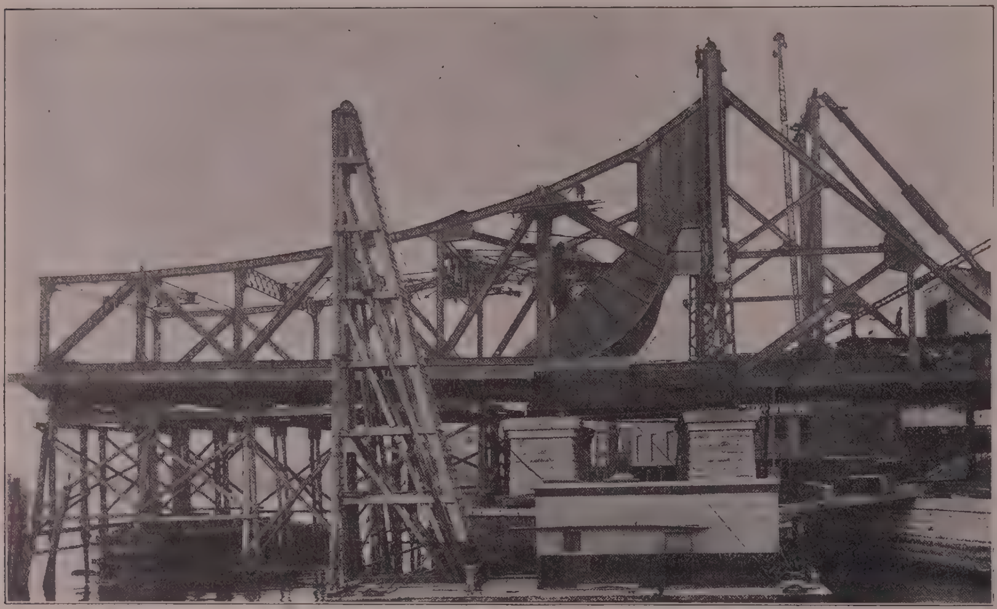
The first explorations were made on the twelfth day, when the ground was found to be frozen from 2 to 4 in. beyond the lining. On the nineteenth day it was frozen from 9 to 12 in., and on the twenty-seventh day from 14 to 17 in. on the south side, and from 28 to 31 in. on the north side at the upper end. Here the correction to the grade was only 6 in., and this amount was considered sufficient to allow the tunnel plates to be removed and excavation be made in the frozen material for the reconstruction. The work, however, was terminated at this point, so that this was not accomplished. The difference in thickness of the frozen zone on the opposite sides of the tunnel was accounted for by the theory that the tunnel tubes intersected the flow of ground water, rising at one end above its surface and acting as a dam to intercept it, thus causing a variation on the lower side where the ice formed 6 to 8 in. thicker than on the upper side.

The results of the freezing process, as far as carried, were considered by the contractors and engineers to be entirely satisfactory and to promise a successful result for the reconstruction of the line, when they were stopped by superior authority, and it was decided to conduct the reconstruction by different methods. The work was done by the New York Tunnel Co., Mr. D. L. Hough, president, under the personal direction of Mr. J. E. Starr, consulting engineer, and Mr. C. R. Forth, assistant in charge.

Measurement of Coal Consumption is made by a novel method at the new Port Morris power station of the Electric Zone of the New York Central R. R. The down spouts from the coal storage bunkers to the stoker hoppers are fitted with shut-off gates at either end, the capacity of the spouts between gates being 1,000 lbs. The handle of the lower gate is connected to a serial counter, and the procedure is, after filling the downspout by the upper gate and then closing, to open the lower gate, by which 1,000 lb. is delivered to the stoker. The counter automatically records the number of such deliveries and the coal consumed with a fair degree of accruacy.

The Erection of the Newtown Creek Bridge.

The highway bridge over Newtown Creek, Borough of Queens, New York, consists of two approaches connected by a two-leaf Scherzer draw span of about 150 ft. clear opening. It replaces an old bridge having a center pier which was not removed until the completion of the new structure, although the superstructure of the old bridge was removed and traffic diverted to other bridges, navigation being maintained without interruption.



Bascule Leaf Erected on Trestle Falsework.

The water had a depth of about 21 ft. at low tide and the bottom was earth and mud, soft on top. As the opening on one side of the old center pier sufficed for navigation, and the pier itself, together with its fender piles, formed a suitable protection, it was considered advantageous to build falsework between the pier and one abutment for the erection of one leaf of the bascule which was accordingly assembled in a horizontal position while the other leaf was assembled in a vertical position in the ordinary manner.

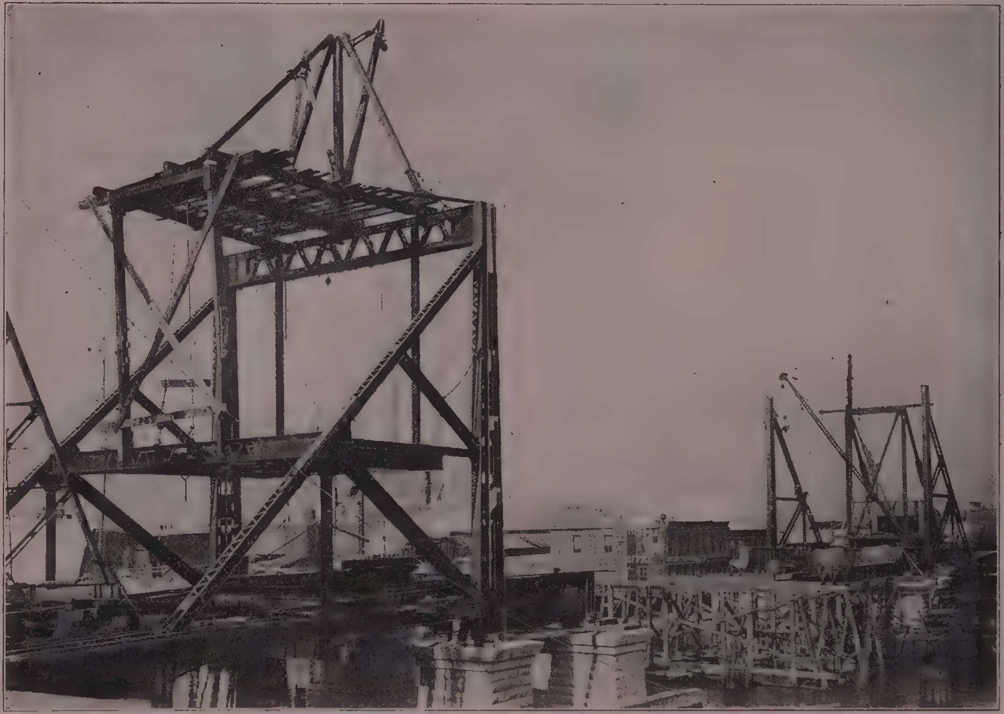
At the time of its erection, this was one of the largest bascule spans then constructed and its erection was a matter of considerable importance. Transverse bents of piles were driven on one side of the channel and were capped with floor timbers, on which the half span was assembled by the traveler which had previously erected the adjacent approach viaduct. It consisted of a horizontal rolling platform with two vertical masts, one on each forward corner. Each mast had two stiff legs and the tops were connected by a horizontal transverse strut projecting 10 ft. beyond each side and serving for the support of hoisting tackles between the masts and on the overhangs. Each mast was fitted with a long steel boom operated by a Mundy hoisting engine on the traveler platform.

The traveler first erected the vertical towers outside of the trusses and passing between them moved to the center of the channel, assembling the floor system as it advanced. Returning it assembled the trusses and transverse bracing, completing the erection as it retreated beyond the pier.

The erection on the other side of the channel was commenced by a similar traveler which had previously completed the erection of the adjacent viaduct. It had booms of sufficient length to erect the tower and the lower end of the span. Afterwards a falsework platform was established on the top of the tower and a stiff-leg derrick installed on it and operated by a hoisting engine on the deck of the approach. With this derrick, the trusses were completed, the boom being extended during the latter part of the work sufficiently to reach the most distant parts of the structure.

The rocker girders were very carefully located on their tracks and as the trusses were connected to them, timber braces were placed between them and the tower to prevent displacement. The counterweights were assembled as the work progressed, care being taken to always have enough in position to maintain stability. The bridge is designed so that the friction is sufficient to give it stability in any position between extreme limits, considerable force being necessary to commence or maintain its movement. This stability was not, however, entirely relied upon during erection, and the braces above mentioned were provided and the top of the truss was also guyed with steel cables. The connections were riveted by pneumatic hammers while the trusses were in the vertical position and advantage was taken of the horizontal position of the floorbeam webs to use them as platforms for the riveting gangs.

The total weight of the bridge is about 200,000 lb. It was built under the direction of the department of bridges, New York City, while Mr. O. F. Nichols, was chief engineer. The American Bridge Co. was the contractor for the fabrication and erection of the superstructure, Mr. A. B. Lueder, assistant engineer in charge of erection.



Commencing Erection of Bascule Leaf in Vertical Position.

Injury to Concrete by Water.

An unusual instance of the injury of limestone concrete by soft water was described before the Institution of Civil Engineers on Nov. 27 by Mr. M. R. Barnett. The soft Thirlmere water of the Manchester supply was found to have acted on the limestone of a 3-mile length of concrete aqueduct so severely that a total leakage of 1,250,000 imp. gal. per day was taking place, although the workmanship on the conduit had been of an excellent character. In order to examine the interior of the aqueduct short lengths were successively shut off by timber bulkheads, and the investigation thus made showed, in some places, holes in the invert through which the water was escaping, and all the small individual pieces of limestone were much water-worn. Physical and chemical tests showed that from 7 to 18 per cent. wastage per year occurred in limestone blocks while mortar blocks gained somewhat in weight. The mortar was mixed 1 : 1, using Portland cement, and its weight increased during three months' immersion in Thirlmere water at the rate of 3.57 per cent. annually, while blocks of neat cement showed an increase at the rate of 5.47 per cent. It was decided that the best way of stopping the leakage was to resurface the whole surface of the concrete in which limestone had been used with 1 : 1 Portland cement mortar not less than 1 in. in thickness. To do this some special devices were employed to remove the necessary surface thickness from the old concrete and to apply the new mortar facing, which were described in detail by Mr. Barnett in his paper. The mortar was put in between timber framework fixed so as to give the cement thickness and maintain the original dimensions of the culvert, which it was very desirable to retain. The surface of the invert was hacked off and replastered after the side walls had been done. The handling of the outside ground water became quite a problem; in all cases free vent was given to the water by the insertion of pipes of suitable platforms for the riveting gangs, a purpose which they very conveniently served.

The Hydro-Electric Plant of the Belton Power Co.

By George Wrigley.

The generating plant of the Belton Power Co. is located on the Saluda River, at a point about seven miles east of the town of Belton, S. C. The river, at the location of the plant, encounters a series of rapids, and the hydraulic development adopted utilizes to the best advantage the fall due to these rapids.

The Saluda River, one of the tributaries of the Congaree, rises in the foothills of the Appalachian Mountains and drains a basin of approximately 534 square miles above the Belton dam. The absolute low water flow of the river was found to be 270 cu. ft. per second at the plant site. The normal flow does not, however, run lower than 600 cu. ft. per second for 90 per cent. of the time. As the principal users of the power are cotton mills, operating for eleven hours a day, the impounding reservoir was designed with a capacity best suited to this character of load.

The hydraulic development consists essentially of a dam and reservoir, a canal, forebay, penstocks and wheels, from which the water is discharged into the tail race, and returns to the river.

The dam is a structure of cyclopean concrete, with a spillway 319.5 ft. long, one abutment 94 ft. long and one abutment 177.5 ft. long, the latter containing the head gates, trash racks and sand gates, with the operating mechanisms for these devices. A floating log boom protects the trash racks from injury by heavy driftwood.

Dam and Headworks of Canal of the Belton Power Co.

The foundations for the entire dam and the anchorages for the abutments are laid on the bed rock. An ample supply of granite was found in the excavations and the near proximity, and this stone was used in the construction of the dam and other parts of the plant. Southern States Portland cement was used throughout in the concrete work, the standard mixture being one part of cement to two and one-half parts of sand and five parts of two-inch mesh broken stone.

The entire dam is faced on the upstream side with a layer of massive granite, approximately two feet in thickness. This face of the dam is vertical, the batter being on the downstream side.

The canal, conveying the water from the head gates to the forebay, is parallel to the general direction of the river and has a length of 816 ft. One wall of the canal consists of a cut in the hillside; the other, or river side wall, being formed, for a part of its length, by an earth fill over a concrete core wall, and is protected, where necessary, with stone filling. The cut has a slope of 1 to 1, and the fill a slope of 1½ to 1.

Immediately below the head gates in the river side wall of the canal is placed an auxiliary spillway, having an elevation of one foot more than the main spillway, and sufficient area to discharge all of the water which the head gates are capable of admitting. This spillway protects the canal and forebay from overflow in case of a sudden shutdown of the water wheels, from any cause.

The forebay, like the main dam, is built of cyclopean concrete and contains a second pair of trash racks, the penstock gates and the air vents. The penstocks are, in reality, simply extensions of the wheel casings, and are securely anchored into the forebay masonry. The penstocks and wheel casings are made of three-eighths-inch boiler plate, single-riveted.

It was found expedient to run the county road immediately over the wheel casings, so the penstocks and wheel casings were encased in a mass of concrete masonry, forming a practically solid structure from the forebay to the power house wall. Each of the penstock gates is fitted with a priming or filling gate to facilitate operation. Manholes in each wheel casing provide access for inspection and adjustment.

Each of the main prime-mover units consists of a set of three, thirty-nine-inch inward flow turbines, fitted with cylindrical gates and having an aggregate capacity of 1,700 h.-p. per unit at full gate when operating under 35 ft. head and running at a speed of 200 r.p.m. Three of these units are installed, each unit being directly connected by a face plate coupling to a 1,000-kw. generator. A 15-in. turbine is installed for driving one of the exciter units and an 18-in. turbine for driving a small alternating-current generator.

The speed of each of the main units is controlled by an "Improved Holyoke" governor, operating on oil pressure, and furnished complete with oil tanks and pressure pump, the pump being belt-driven from the shaft of the prime-mover unit. A small compensating Woodward governor is installed for each the 15-in. and the 18-in. wheels.

Draft tubes of ample cross-section convey the water from the wheels to the tail-race, the ends of the tubes being well submerged and the tail-race excavated for a sufficient depth immediately below the tubes to prevent foaming. The normal elevation of the tail-race water is 36 ft. lower than the crest of the spillway of the main dam. The tail-race is approximately 338 ft. long, and is lined with massive stone masonry set in cement.

The generating machinery is placed in a substantial brick and steel building, 83 ft. long and 35 ft. wide and resting on the concrete arches and bed rock foundations. The building is provided with ample window openings and has a large monitor in the roof, giving good light and ventilation. The floor of the power house is served by a Niles-Bement-Pond traveling crane of 15 tons capacity. The step-up transformers are placed in a separate room at one end of the main building. This room contains also the lightning arresters, oil switches, etc., and is separated from the main building by a fire wall fitted with an automatic fire door placed on a level with the switchboard gallery.

The main electrical generating units consist of three 1,000-kw., three-phase, 2,300-volt, 60-cycle, revolving-field generators, each directly coupled to one set of three water wheels and running at a speed of 200 r.p.m. A 100-kw., three-phase, 60-cycle generator, running at a speed of 600 r.p.m., and generating current at 2,300 volts, is directly coupled to the 18-in. water wheel. This unit is used at night for lighting service, after the main power generators are shut down. A 5.5-kw. exciter is provided for this generator and is driven from a pulley on the extended shaft of the generator.

The plant is equipped with two main exciters, one of 55 kw. capacity directly coupled to the 15-in. water wheel and running at a speed of 625 r.p.m., and one of 58 kw. capacity at 925 r.p.m., the latter so arranged that it can be driven by a belt from a pulley on the shaft extension of either one of two of the main generators. The water wheel-driven exciter gives somewhat better voltage regulation and is used in normal operation, the belted machine being held as a reserve. Each of the exciters has sufficient capacity to excite all of the main generators, under the extreme conditions of load and power factor met with in the operation of the plant.

The cables connecting the generators with the switchboard are insulated with varnished cambric and are lead-covered. These cables are laid in impregnated fibre conduit, set in the concrete floor of the station. The switchboard is mounted on a gallery at one end of the power house, and immediately in front of the transformer room. The gallery is of sufficient height to enable the operator to have an unobstructed view of all the machinery. The switchboard consists of four generator, two exciter-generator and two step-up transformer panels. The oil switches for the generator and transformer panels are placed in separate cells mounted on a gallery in the transformer room (this gallery being a duplicate of the one in the main room and placed on the same level with it). Operating rods run through the dividing wall and connect the oil switches with their respective mechanisms on the face of the switchboard. The generator switches are non-automatic, the transformer switches being automatic with time-limit relays.

Installed in the transformer room are six water-cooled 500-kw. transformers, which raise the potential of the system from 2,300 to 22,500 volts. These transformers are installed in two banks of three each, and are delta-connected on both the low and high-tension sides. The water for cooling the transformers is drawn direct from the penstocks. As this water contains, at times, a considerable quantity of silt, liable to precipitation in the cooling coils, a pressure pump is installed for blowing out the sediment at intervals. Each bank of transformers is connected to a set of high-tension bus-bars, which are in turn connected through the medium of air break disconnecting switches to the one outgoing line. During normal day load operation both banks are connected to the line and operated in multiple, but at night only one bank is retained in service. The lightning arresters also are placed in the transformer room.

End of Forebay and Power Station, Belton Power Co.

The three conductors of the transmission line leave the transformer room through terra-cotta tiles, set in the wall at an angle to prevent the entrance of rain. From the generating station the first section of the transmission line is carried to a junction point, from which the lines to Belton and Williamston diverge. This first section of the transmission line is 4.1 miles long and consists of three cables of 165,160 cir. mils each. The line from the junction to Belton is 4.4 miles long, with 103,800 cir. mils cables, and the line to Williamston, 5 miles long, with 82,340 cir. mils cables. All of the power conductors are of aluminum, seven-strand cable. Joints were made in the cable, where necessary, with flat aluminum tubes, of such size as to snugly fit the ends of the cable and firmly secured by two complete twists.

The power conductors are placed in the form of an equilateral triangle with a distance of 48 in. between centers. Poles are spaced 120 ft. apart on the levels and the average height of the lower conductors above level ground is 30 ft. The pole line is carefully graded in height, by using long poles in the low places and short ones on the crests of ridges. The poles and cross arms are of pine, impregnated by vacuum process with creosote.

Lightning phenomena in this section of the country are very severe, and a grounded guard conductor is installed to assist in eliminating disturbances on the transmission line. This guard conductor consists of a 3/16-in. galvanized steel cable, supported by the lower cross arm to which it is secured at the side of the pole, its position being practically at the center of the base of the triangle of power conductors. The guard conductor is grounded thoroughly at every sixth pole.

One sub-station is located at the town of Belton, the other at Williamston. The sub-station at Belton contains three 667-kw. water-cooled transformers, stepping down from 22,500 volts to 600 volts. These transformers supply power to the Belton Mills. The Williamston sub-station is practically a duplicate of that at Belton, except that the apparatus is smaller. Three 333-kw. transformers supply power at 600 volts to the Williamston Mills, and a single 25-kw. transformer is installed for the lighting of the town.

Both the Belton and the Williamston Mills are equipped with complete steam plants, having been so operated before the advent of the electric power. These steam plants are now held as reserves and are ready for prompt service in the event of an accident to the electric system. The shafting of the mills is so arranged that the drives can be changed from electrical to mechanical, or vice versa, in a very short time. The group electric drive is used in both mills, induction motors of standard speeds and varying in size from 50 to 300 h.-p. being installed. The load is practically constant for 11 hours during the day; and as there is no night work in the mills, only the comparatively small lighting load of the towns is carried during the night.

The water-wheels, together with the gate irons, penstocks, draft tubes, governors and other accessories were furnished by the Holyoke Machine Co., of Worcester, Mass. The entire electrical equipment, including the apparatus for both the sub-stations and the generating station, was furnished and installed by the General Electric Co. This same company furnished and installed also the electrical equipment in both of the mills. The complete hydraulic and electric plant was designed by and constructed under the supervision of Mr. J. E. Sirrine, of Greenville, S. C.

Tail Race and Power Station, Belton Power Co.

Notes on the Sewers in Manhattan Borough, New York City.

The topography of Manhattan Island, with its long and narrow shape, is very favorable to a simple and direct system of sewers, which consists essentially of numerous transverse outfall lines emptying into the rivers on both sides of the island and receiving short longitudinal collecting branches of small diameter. The aggregate length of the system is about 515 miles, composed of vitrified pipes 12, 15 and 18 in. in diameter and brick sewers varying from 2x3 ft. elliptical sections to 6 ft. circular sections.

Except in the northern part of the borough and in a few other small areas which have not yet been sewered, the system is substantially complete, and the principal work of the department is in maintenance, repairs and reconstructions, comparatively few extensions being required. There is very little concrete construction, because of the opposition to it by brickmakers and bricklayers, and because of the greater difficulty in making connections to a completed sewer. Reinforced concrete is not used in any part of the system because the dimensions of the structures are not great enough to make it an economical construction. A few short sections of iron pipes are used, principally in cases where the head room is limited and especially for the subway crossings.

Most of the outlets are made with wooden stave pipes carried under the piers and having their ends submerged at high tide. Originally these outlets, from 3 to 5 ft. in diameter, were made in 15 or 20 ft. sections, secured together with butt joints and wide iron sleeves. It was found that the impact of vessels against the piers loosened the joints and sometimes entirely destroyed them so that whole sections of pipe dropped out. They are now built in position with staves breaking joints throughout the circumference of the sewer so as to form a continuous structure which satisfactorily resists distortion and displacement. They generally terminate 5 or 10 ft. from the ends of the piers, so as to be concealed and avoid discharging their contents directly against boats which may be moored there. These pipes are sometimes as much as 600 ft. long, have scarcely any grade and are submerged with every tide. The flow through them is therefore intermittent, and although the velocity is so much reduced, they are generally clean on account of the smoothness of the interior. The case is, however, different with the brick sewers built on the low, flat made land close to the water's edge; all of them contain large quantities of mud, due to the lack of scour.

Obstructions are very much increased by the improper use of the sewers. In some districts it is a common practice to remove the manhole covers and dump garbage and refuse into them. The flushing of mud and dirt from the streets into the catch basins is also very objectionable. In the winter, the manholes are frequently opened and used as shafts for the disposal of snow, ice and the mud which is gathered with them, by the street department. When a manhole is filled with a mass of this nature with insufficient water in the sewer to melt it, a serious obstruction is formed which in some cases may freeze solid and cause considerable difficulty. Various methods have been proposed for the protection of the manholes, but as there are about 25,000 of them in the city, any system of locking them is considered expensive and impracticable. A special type of manhole cover, devised to lock itself automatically and be removable only by the sewer department, was proposed but was not considered sufficiently reliable to be adopted. A large amount of cleaning, which might be avoided, is therefore necessitated and is accomplished wholly by hand, men entering the sewers and shoveling the dirt into buckets which are hoisted through the manholes.

The 12 and 18 in. sizes of pipe sewers and the curved connections formerly used with them, have been eliminated to some extent, and now only straight lengths of 15 in. pipes, rarely more than one block in length, are used. Wherever a curve is necessary, they terminate in brick construction. Manholes are provided for them 100 ft. apart, and they are cleaned by means of a hose taken to the foot of the manhole. Flushing tanks have been recommended, but are not provided.

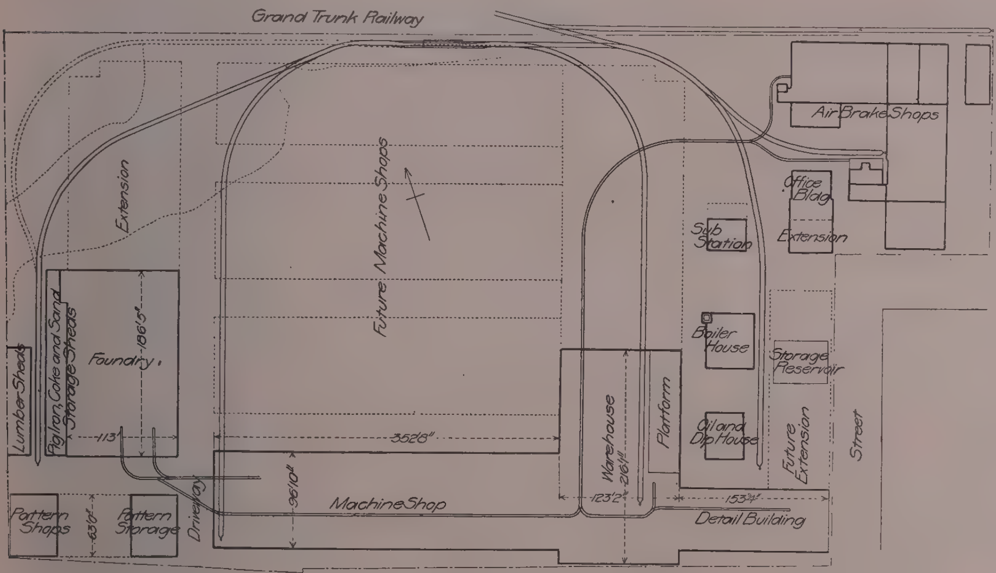
The pipes used are made with straight ends laid with butt joints enclosed in sleeves. The latter are made in three pieces and are assembled as the pipe is laid with cement mortar around the joint, which is thus always visible and can be easily made thorough and tight. The brick sewers are carried on pile or timber foundations where the ground is soft enough to make it necessary. One of the worst cases of settlement occurred at Twenty-seventh St., and North River, where a 4-ft. sewer was carried over made ground deposited on an old swamp. It is supported on piles, which were driven with great difficulty, many of them at first rising several feet when left over night. They were finally kept down by building a platform on top and loading it quickly, and the sewer was thus completed, and the street built over it. In a few years both street and sewer settled several feet, so that the crown of the sewer was lower in places than the invert should be, and finally a second-story sewer was built over the low portion and is now in service.

Many of the original sewers were built of uniform diameter from end to end, thus providing an unnecessary size in the upper part. In other cases the capacity was originally sufficient, but has become overtaxed by the greatly increased storm flow due to the enlarged area of roofs and pavements discharging into them. Many of these sewers have been reconstructed. The principal difficulty met is on account of the limited space available in the streets, which barely suffices for the single system and is considered entirely inadequate for the separate system, which has been suggested and would, if practicable, be desirable in many instances, where the present sewers, relieved from the storm flow, would be ample for the house service.

The construction of new buildings and excavations in the street and adjacent to them necessitate many repairs to the sewers. In some cases, where deep excavations are sheeted down close to the sewers, the latter are injured or destroyed even when no undermining takes place, because the lateral pressure on one side is reduced and the unbalanced pressure, together with the friction of the sheet piles, causes the walls and arch to collapse, especially if the mortar is poor. In such cases an old structure that would have remained stable under balanced pressure is likely to fail completely.

All of the new work of magnitude is built under contract, but maintenance and repairs are done by day labor. The department has two yards in different parts of the city, which are equipped with a large stock of materials and tools and where the men report daily for service. The total force of the department is about 300 men, including assistant engineers, inspectors, clerical employees and laborers. All work is conducted under the direction of Mr. Horace Loomis, chief engineer.

INTERMITTENT FLOWING WELLS are so rare that one at Albany, Ga., deserves mention. According to Mr. Charles Tift, formerly city engineer of that place, an 8-in. well was sunk into the cavernous limestone underlying the city, to serve as a drain for a pool of surface water covering about half an acre and averaging 18 in. in depth. At a distance of 90 ft. below the surface, a cavity 6 or 8 ft. through was encountered. The drill was withdrawn and the water drained into the hole, which it did not fill. About six minutes later, the water began to bubble and almost immediately the entire column of water was thrown perhaps 30 ft. into the air. This draining and ejection was repeated with diminishing force for over an hour, and the same phenomenon occurs whenever a heavy rainfall fills the pond.



General Plan of the New Canadian Westinghouse Works at Hamilton, Ont.

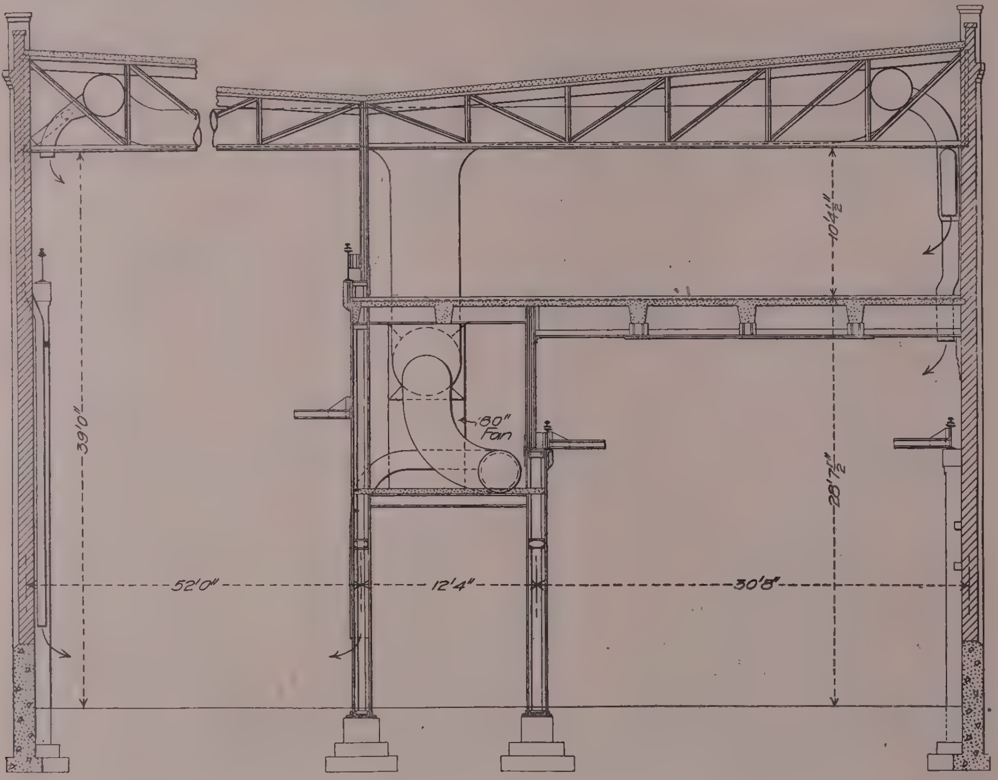
New Works of the Canadian Westinghouse Co. at Hamilton, Ont.

The Canadian Westinghouse Co. has recently completed, at Hamilton, Ont., an extensive manufacturing plant which, being an entirely new establishment, could be constructed unhampered by any requirements to make it supplement existing works. Full advantage was taken of the opportunities afforded for the adoption of the most approved and efficient methods of design and construction and the result is a very convenient arrangement of buildings for handling the product under manufacture, while the unit costs of construction of the buildings were unusually low.

The new plant is intended for the manufacture of the greater part of the electrical products of the Westinghouse Electric & Mfg. Co., of Pittsburg, Pa., which are used in Canada. It has been located on a 536x832-ft. plot, adjoining the works of this company at Hamilton, which has been in operation for several years in the manufacture of the Westinghouse air brake equipment. The site is in the eastern portion of the city adjoining Lake Ontario and is convenient to the main line of the Grand Trunk Ry. for shipping connections. The ground is high and well drained, the grade averaging from 20 to 25 ft. above the lake, and is level with the exception of a gully at the northwest corner of the site, at present unoccupied, which will be filled. The site is within the city limits so that the city water and sewer services are available.

The layout of the plant was planned in accordance with the extended experience gained at the Pittsburg works of the Westinghouse companies. The general scheme comprises, as shown in the accompanying plan, at the front, a long machine shop, at one end of which is grouped a foundry with pattern-shop and pattern storage buildings, lumber sheds and foundry materials storage; and at the other end a detail building and large warehouse, together with auxiliary buildings, including an oil house, boiler house and sub-station for the power system, power being purchased from a local water power plant. In the plan are also shown the provisions made for extension of plant. The buildings now completed have been located on the portion of the property farthest from the adjoining railroad and connecting side tracks and all future extension will be made in the direction of the tracks. For the machine shop, one of the most important sections of the works, the possible extension provides three additional buildings, all duplicating the present shop. Similarly, both the foundry and the warehouse, which are arranged at right-angles to the machine shop, may be extended longitudinally in the same direction, while the detail building at the easterly end of the plant will have an extension in the same direction, toward the office building. The new plant will thus remain entirely distinct from the air brake shop yet conveniently adjoining so as to permit of a common heating and lighting service, and administration. For executive purposes the original office building has been extended to serve for the new works in addition.

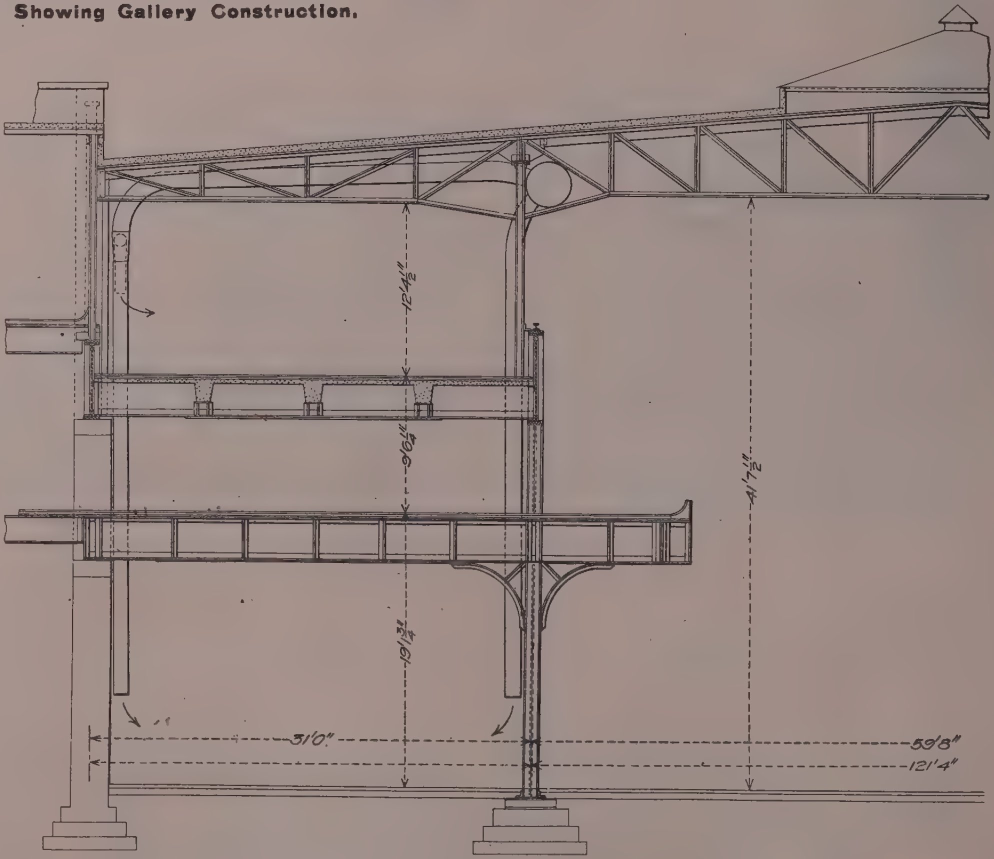
The buildings have steel frames, concrete footings, brick walls, and reinforced concrete roofs and gallery floors, with the exception of the pattern shop, pattern storage building and detail building, which are of reinforced concrete construction throughout. A feature of the construction is the extension of the concrete footings up to the level of window sills, in all of the buildings, the brick walls commencing at this point in all cases. The floors are in general of concrete, faced in portions of the machine shop and working departments, with 1 in. square edge maple, and elsewhere with 1 in. of granolithic finish. Unusually good daylight lighting has been provided in all of the buildings, but without overhead lighting in any of them except the warehouse, where skylights are used; monitor construction has been avoided entirely.



Cross-Section of Machine Shop, Showing Gallery Construction.

Machine Shop.—The machine shop is 96 ft. in width by 352 ft. in length to the point of juncture with the warehouse and has two bays, one 52 ft. in width accommodating heavy machine work and the other a 42 ft. 10 in. bay with gallery, for work of lighter character. At the inner side of the narrower bay, there is an intermediate mezzanine floor underneath the gallery for the toilet and locker rooms. The wide bay has an unobstructed headroom under roof beams of 37 ft., while the clear headroom in the narrow bay is 25¾ ft. below the gallery and 10½ ft. above the gallery floor. The mezzanine and gallery floors are supported in part by the line of steel posts in the center of the building and in part by an intermediate row spaced 12 ft. into the narrower bay. This arrangement of the interior affords an unusually convenient location of the toilet and locker rooms, which, being on the mezzanine floor in practically the center of the building, are most accessible to the workmen, and owing to their location in the center of the building, do not interfere with the lighting of any portion of the interior.

The floors of both the mezzanine and the gallery are of reinforced concrete, the former carried on 10-in. I-beams and the latter on 32-in. transverse plate girders, all spaced in 15-ft. bays. Between these, for the gallery floor, there are 20-in. reinforced concrete girders of tapering section, 16 in. wide at the base, reinforced by three Kahn bars, and spaced on 6 to 8-ft. centers. Upon these concrete girders is a floor of 4½-in. concrete slabs, reinforced by ¾-in. Ransome bars, upon which is laid a granolithic finish 1 in. thick. The roof construction is unusual in that it is graded to drain toward the center, both sides dropping from the parapet walls 3 ft. 7 in. to the line of posts in the middle of the building, which carry the inner ends of the roof trusses. The roof covering is similar to that of the gallery floor, consisting of 4½-in. slabs reinforced with ¾-in. Ransome bars 14 in. between centers; the slabs being laid directly upon the roof trusses, without purlins, and with the reinforcing bars arranged longitudinally.



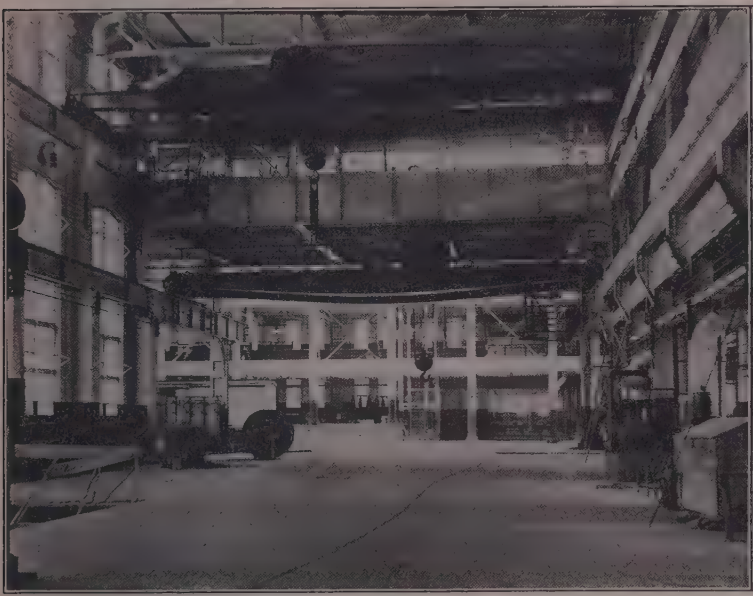
Half Cross-Section of Warehouse, Showing Auxiliary Crane Runway.

The warehouse, which joins the machine shop transversely at its eastern end, is a large three-story center-bay building, 123 ft. in width and 216 ft. long, with provision for an extension longitudinally toward the north, so as to join with the easterly end of each of the proposed machine shops. When fully extended it will have a total length of 500 ft. The building has a 60-ft. crane-traversed center bay, with 41 ft. clear headroom under roof trusses and two 30 ft. side bays, each with two galleries. The lower galleries are 15 ft. above the floor line and the second galleries are at an elevation of 28 ft. above. The floor and roof construction is here similar to that of the machine shop, concrete slab construction being used throughout. The roof design, however, differs from that of the machine shop, in that it is drained toward the sides and is, owing to the width of the building, surmounted by a skylight 24 ft. wide over the center bay. The center bay roof trusses have a clear span of 61 ft. 7 in. and are specially detailed to admit of 40-in. hot air ducts at either side for the heating system.

The foundry, at the westerly end of the plant, occupies a building of similar construction to the warehouse, having a wide crane-traversed center bay and two narrower side bays. This building is 113 ft. in width and 186 ft. long, provisions for extension permitting its length to be increased to 400 ft. The center bay is 50 ft. in width and has a clear headroom underneath roof trusses of 35 ft. The single-story side bays are 30 ft. in width and each has a headroom of 24 ft. The center bay roof is carried by steel trusses of 51 ft. clear span, with concrete slab roof covering, but is without skylight, center lighting being afforded by rows of windows in the wall construction above the side bay roofs. The side bay roofs, which are also of concrete slab construction, similar to that of the machine shop and warehouse buildings, are carried by 28-in. concrete beams of 30 ft. span; these beams are reinforced by three 1¼-in. Kahn bars and two ¾-in. round rods, spaced 4 in. between centers, which extend from the webs of the crane posts to anchor plates in the outer walls; a detail of the attachment to the crane posts is shown in an accompanying drawing.

The detail building, which adjoins the warehouse building at its point of juncture with the machine shop, is a 63x153-ft. structure entirely of reinforced concrete. It is three stories in height, with concrete columns, girders, floor and roof slabs. The columns are arranged in two longitudinal rows through the middle of the building, spaced 15 ft. apart on centers and giving 24-ft. bays on either side. The side bay floors are carried by 29-in. concrete girders, 21 in. in width at the top and 17 in. wide at the base, each reinforced by three 3¼ and two 2¾-in. Kahn bars. These girders are spaced 15 ft. apart and between them are located smaller longitudinal girders, spaced

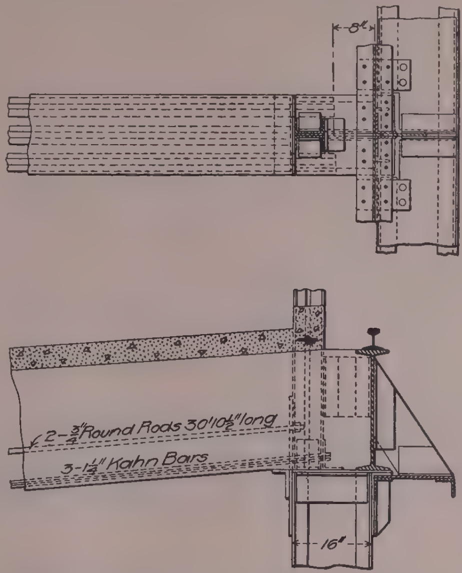
7½ ft. apart, supporting the floor. These are 18 in. beams each of which is reinforced by three 3-in. Kahn bars. The concrete posts supporting the second and third floors are each 20 in. square and reinforced by four 1-in. Kahn bars; those supporting the second floor are 15x15-in. posts reinforced by four ¾-in. Kahn bars and those supporting the roof 11x11-in. posts with four 2¾-in. Kahn bars. The roof on this building is graded to drain from the parapet walls toward the center.


View in High Bay of Machine Shop at East End.

View in Low Bay of the Machine Shop.

Crane facilities have been provided in abundance in the shop buildings, which, in conjunction with the standard and narrow gauge material handling tracks, provide ample mechanical facilities for handling materials and equipment. The machine shop has a 10-ton crane of 50-ft. span over its wide bay and a 5-ton crane of 28½-ft. span over the narrow bay, both of which travel the entire length of the building. At the juncture of the machine shop and warehouse, provisions were made for the handling of loads directly from one building to the other by the cranes alone. The runway of the main 10-ton machine shop crane is cut off from entrance to the warehouse by the warehouse galleries on the westerly side and accordingly an auxiliary crane of similar capacity has been installed at a low level at the easterly end of the machine shop so as to carry loads from the machine shop under the gallery to the warehouse. This auxiliary crane, which has a 48-ft. span, has a short travel of about 100 ft. at the east end of the building and is carried on a runway 18 ft. above the floor. This runway projects 10 ft. out beyond the building columns into the center bay of the warehouse so that loads may be rehandled from the machine shop crane directly out into the warehouse for lifting by the warehouse crane. The warehouse is traversed by a 15-ton crane of 59 ft. span, which is carried on runways 32 ft. above the floor. The foundry has three cranes, a 10-ton crane of 48 ft. span in the center bay, a 5-ton crane of 27 ft. span in one of the side bays and in addition a traveling jib crane with arm overhanging 20 ft. on the cupola side of the center bay. Two of the larger cranes were built by the Morgan Engineering Co., and the remainder, including the jib cranes, by the Northern Engineering Works, Detroit, Mich.

Ample shipping facilities are provided by both standard and narrow gauge connections to all buildings. The standard gauge tracks connect with the adjoining railway sidings, and have branches extending longitudinally through the warehouse, through the westerly end of the machine shop, alongside of the foundry and to the rear of the boiler house and detail building. The narrow gauge system is an industrial railway of 24 in. gauge which extends longitudinally through the machine shop, into the foundry, the warehouse, the detail building, and across to the air brake works at the easterly end of the site. This system is installed essentially for the handling of castings but is available for all classes of material. The track work for the latter system was built by the Montreal Steel Works, and the cars supplied by Arthur Koppel Co., New York.



Detail of Side Bay Roof Girder Construction in Foundry.

The heating of the shop buildings is accomplished by warm blast in all of the larger buildings, warm air being distributed at the temperature of 120 deg. Fahr. by steel plate centrifugal fans which draw the air through cast iron heating coils. The buildings thus heated are the machine shop, warehouse, detail building, foundry, pattern shop and pattern storage building. Although the first three mentioned are used for different purposes, they are so intimately connected structurally that they are treated as one building so far as the heating arrangements are concerned, the warehouse receiving part of its heat from the fan in the machine shop and part from the fan in the detail building. In all but the foundry the air is re-circulated, fresh air being there introduced for ventilation purposes.

The heating plant in the machine shop consists of a 180-in. fan built by Sheldon & Sheldon, of Galt, Ont., operated by a 30-h.-p. motor which has a rated capacity of 3,485,000 cu. ft. of air per hour. The heating stack consists of 180 Stirling indirect cast-iron sections having a total of 3,600 sq. ft. of heating surface, which coils give off 2,880,000 B. t. u. per hour to the air passing through them, and since the air is re-circulated all of this heat is used in warming the shop, in which a temperature of 70 deg. F. is maintained in zero weather. The fan motor is a Westinghouse induction motor and is connected to the fan by a Morse chain drive.

The fans and heating coils in the machine shop are located in the mezzanine floor of the shop near the middle. The general distribution is accomplished through two main distributing ducts carried along the outside walls just under the roof, connecting with the fan by cross ducts passing under the roof and down vertically to the fan outlet, and a third main duct located under the mezzanine floor and close to the center line of the columns, which is supplied directly from the fan outlet. From these main ducts branch outlet flues are carried downward and discharge through outlets near the floor line, all outlets being located about 4 ft. above the floor.

The system in the detail building has a fan of the same capacity as that in the machine shop, but of special construction 160 in. in height, to allow it to be located on the third floor of the building. The heating coils are also of the same size as those in the machine shop system. This fan has two discharge outlets, one of which connects with a main duct which passes along the outside walls of the detail building under the roof, from which flues are carried down the walls and discharge through suitable outlets at the three floors. The other fan outlet connects with ducts located near the outside walls and under the roof of the warehouse, and flues are carried down from these ducts and discharge near the floor.

In the foundry building there is a 100-in. fan operated by a 15-h.-p. motor, which delivers 1,161,600 cu. ft. of air per hour. The heating coils contain 112 Stirling indirect sections having a total of 2,240 sq. ft. of surface which give off 1,792,000 B. t. u. per hour to the air passing through them. Owing to the smoke and gases incident to the operations in this building, ventilation was desired and, accordingly, instead of re-circulating the air in the building, the fan system was arranged to supply fresh air only from outside. The actual heat required to warm the building to a temperature of 60 deg. in zero weather is 1,100,400 B. t. u. per hour and the heat in addition to this amount which is supplied to the air is lost in ventilation. In order to provide for future extension to the foundry building the fan and heating coils are located at the end of the building at which the future extension will be made, thus placing the heating plant at the center of the building after it is extended. The main ducts are carried along the outside walls under the roofs of the side bays, and, as in the other buildings, outlet branch flues pass downward from them and discharge at points located near the floor line.

In the pattern shop and storage buildings a single 90-in. fan is installed for heating both buildings; it is located in the basement of the pattern shop and one of the main ducts is carried to the pattern storage building through a covered trench. The fan is operated by a 10-h.-p. motor and has a capacity of 936,000 cu. ft. of air per hour. The heating coils contain 120 sections of Stirling radiation having a total of 2,400 sq. ft. of surface, which give off 1,920,000 B. t. u. per hour to the air passing through them. Fresh air is supplied to the heaters continually in order to provide for ventilation of the buildings and the actual heat required to maintain a temperature of 75 deg. in the pattern shop is 507,700 B. t. u. per hour, while the heat required to warm the pattern storage building to 60 deg. in zero weather is 347,530 B. t. u. per hour. The total heat required to maintain the desired temperatures in both buildings is therefore 855,230 B. t. u. per hour and the difference between this amount and that supplied to the air represents what is lost in ventilation. The main heating ducts in the pattern shop are located at the ceiling of the basement and in the pattern storage building on the ceiling of the first story. From these, flues pass upward and discharge at suitable outlets at the three floors of the buildings.

The office building, which has been reconstructed to serve the new works by an addition to the original office of the Air Brake Company, is heated by direct radiators, simply carrying out the plan of the old building and extending the system used therein. The remaining auxiliary buildings are also heated by direct radiation. Steam is supplied to the heating coils by two 200 h.-p. Stirling boilers in a boiler house between the old and new plants. They are fitted with plain grates for hand firing and deliver steam at 100 lb. pressure for heating purposes only. In general the heating of the shops has proven very satisfactory and the attention to the matter of ventilation has well repaid the extra cost of installing and operating such a system in increased comfort and efficiency of the employes. The success of these systems has been all the more marked in view of the severe climatic conditions which prevail in the vicinity of Hamilton.

For the protection of the contents of the buildings from fire, automatic sprinklers are placed on all floors of all buildings and there are numerous hydrants in the shop yard, both systems supplied by mains entirely independent of the water supply service. Post indicator valves in the shop yard control the supplies to the various buildings and to the various sections of the sprinkler system. For the water supply the city gravity service is depended upon, which gives a pressure of about 90 lb. An emergency provision for water supply has also been made in the installation of a 200,000-gal. depressed reservoir at the rear of the boiler house and a 1,500-gal. underwriters pump, which may be brought into service in case of fire. The reservoir is of concrete, 43 ft. 8 in. by 58 ft. 9 in. in size, inside, having a depth of 12 ft., and is depressed below the yard level so that when the detail building is extended, it may be built over the reservoir. The sprinkler system was installed by H. G. Vogle Co., New York.

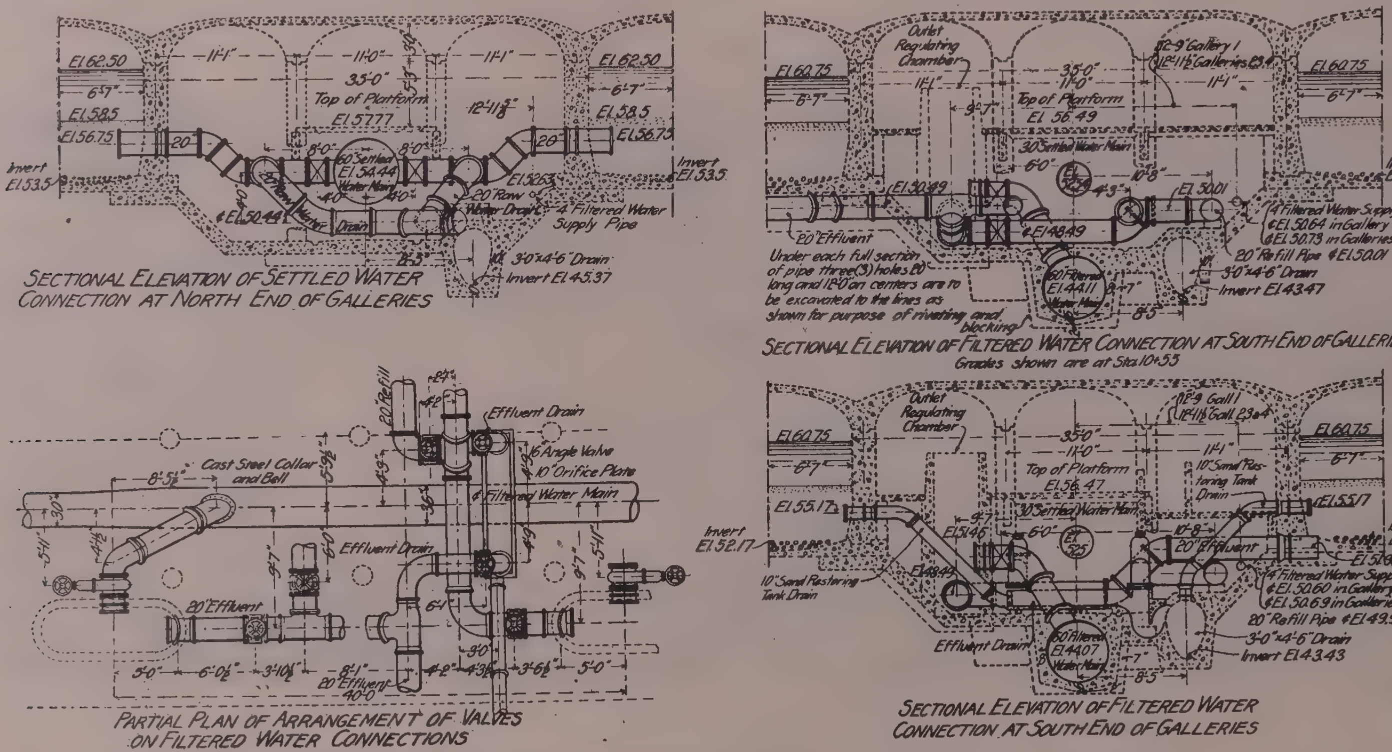
Power for the operation of the shop machinery and lighting is purchased from the Cataract Power Co., of Hamilton, which has an extensive hydro-electric development at the De Cew Falls of the Welland Canal, some 30 miles distant. Power is transmitted at high voltage to a sub-station at the plant, a 32x40-ft. building, at the rear of the boiler house, where it is transformed to a lower voltage for distribution. The shop is electrically driven throughout, for which induction motors are used for the greater part, although direct current service is provided for the operation of the cranes, and for certain variable-speed tools. The buildings are lighted largely by Nernst and Cooper-Hewitt lamps.

This entire plant of the Canadian Westinghouse Co., including shop layout and details of building construction, was designed and constructed by Westinghouse, Church, Kerr & Co., New York.

The Pittsburgh Filtration Plant.---II.

Adminstration Building.—The operation of the entire plant will be controlled and directed from the administration building erected over the central gate chamber. This building has three floors and is situated so it overlooks the whole plant and the site for future extensions. It is of fire-proof construction, is finished in gray brick, trimmed with Cleveland sandstone and has a red tile roof. The first floor contains the operating stands of the gates in the chamber below and the motors driving these gates. The offices of the superintendent of the plant and his assistants, an exchange board of a telephone system extending to various parts of the plant, a machinery room, a blue printing and photographic room and a large storage vault will occupy the second floor. Completely equipped bacteriological and chemical laboratories will be placed on the third floor.

Filter Beds.—The forty-six filter beds included in the plant now being constructed have inverted groined-arch concrete floors and groined-arch concrete covers carried on concrete piers. The design of this concrete work embodies no unusual features, except that the floors are made in two layers, each 4 in. thick, the upper layer being increased to form the inverted arch sections. The thickness of the gravel and sand layer is shown in the accompanying cross-section through a portion of a filter which also shows the details of the concrete construction of the filter floors and covers and the cross-section of the main effluent collector. The maximum depth of sand in the filters will be 48 in. and the minimum depth 24 in. above the top of the gravel.


Sectional Elevation of Settled Water Connection at North End of Galleries
El. 62.50
11'-1"
11'-0"
35'-0"
Top of Platform El. 57.77
El. 58.5
El. 56.75
Invert El. 53.5
60" Settled El. 54.44 Water Main
20" Raw Water Drain
4" Filtered Water Supply Pipe
3'-0"x4'-6" Drain Invert El. 45.37
Sectional Elevation of Filtered Water Connection at South End of Galleries
Grades shown are at Sta. 10+55
Outlet Regulating Chamber
El. 60.75
Top of Platform El. 56.49
30" Settled Water Main
20" Effluent
Under each full section of pipe three (3) holes 20" long and 18" on centers are to be excavated to the lines as shown for purpose of riveting and blocking
60" Filtered El. 44.11 Water Main
4" Filtered Water Supply Pipe
20" Refill Pipe
3'-0"x4'-6" Drain
Invert El. 43.47
Invert El. 52.17
Partial Plan of Arrangement of Valves on Filtered Water Connections
Cast Steel Collar and Bell
Effluent Drain
6" Angle Valve
10" Orifice Plate
Filtered Water Main
20" Effluent
20" Refill
Sectional Elevation of Filtered Water Connection at South End of Galleries
Top of Platform El. 56.47
10" Sand Restoring Tank Drain
30" Settled Water Main
60" Filtered El. 44.07 Water Main
Effluent Drain
20" Refill Pipe El. 49.97
3'-0"x4'-6" Drain
Invert El. 43.43

Sections of Galleries and Details of Piping, Pittsburgh Filtration Plant.

Gravel and Sand.—The gravel is placed in four layers totaling about 1 ft. thick, and consists of four sizes, each graded from large to small stones, as follows: The largest will pass a screen with a 3-in. mesh and is retained on a sieve with a 1¾-in. mesh; the next size will pass a screen with a 1¾-in. mesh and be retained on a screen with a ⅝-in. mesh; the third will pass a screen with a ⅝-in. mesh and be retained on a sieve with a ¼-in. mesh and the smallest will pass a ¼-in. mesh, is coarser than ordinary sand and free from fine material. These four sizes are placed from the floor up in layers of the following thickness: 5 in. of the largest size, 3½ in. of the second size, 2 in. of the third size and 1½ in. of the smallest size.

The filter sand is required not to cause a turbidity exceeding 200 parts per 1,000,000 by the silica standard when 100 grams of it are shaken in a liter of distilled water. The sand in addition is required to pass satisfactory chemical tests and has to meet the following requirements as to size, the diameters of the sand grains being computed as the diameters of spheres of equal volumes and all percentages by weight: Not more than 0.5 per cent. can be less than 0.16 of a millimeter; not more than 10 per cent. less than 0.28 millimeter; at least 10 per cent. must be less than 0.36 millimeter; not more than 60 per cent. must be less than 0.6 millimeter; at least 60 per cent. must be less than 0.75 millimeter; and at least 90 per cent. must be less than 2.1 millimeters. No particles can be more than 5 millimeters in diameter.

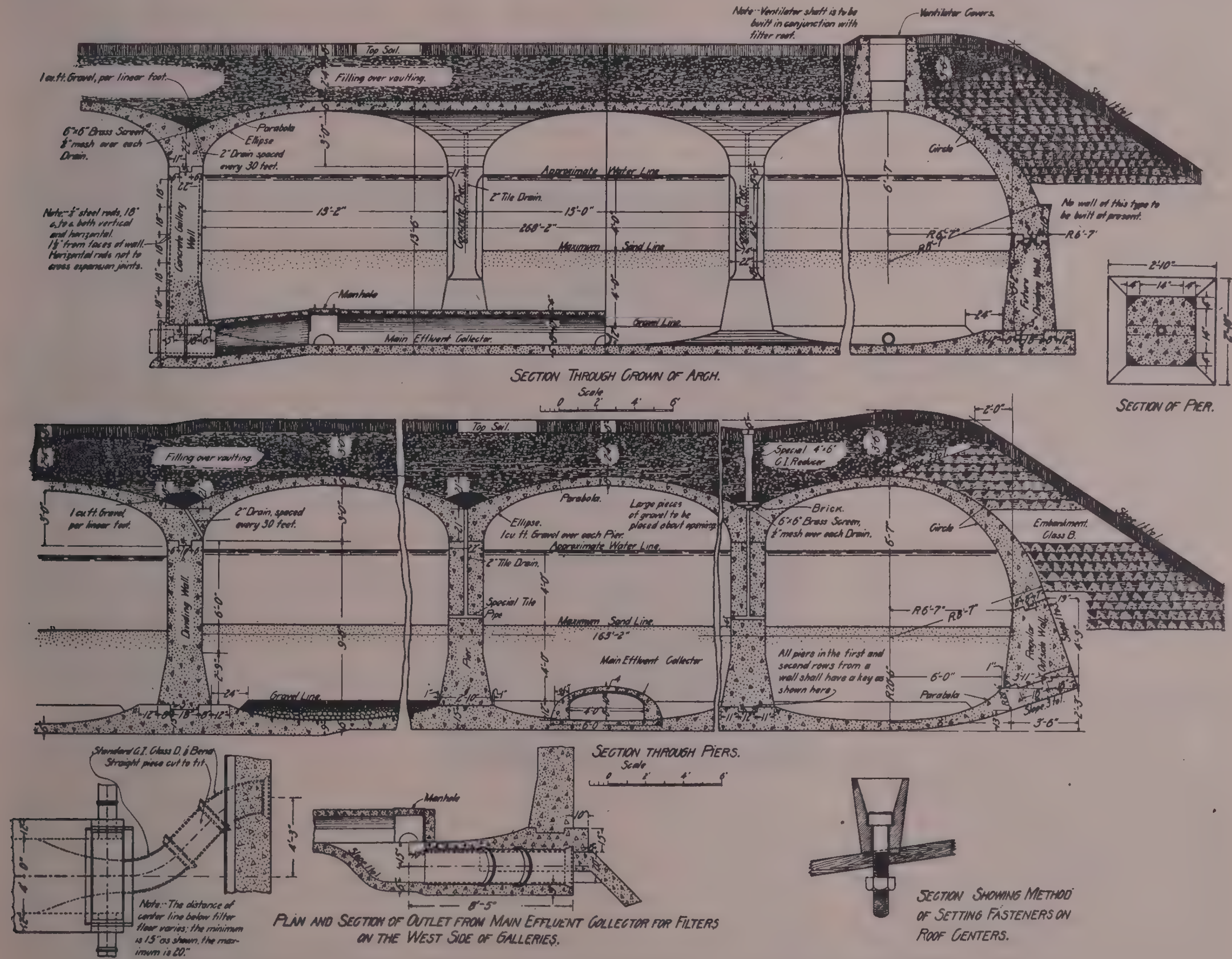
The sand is placed in the filters in three layers of about equal depth. That portion of it in the free spaces between the edge of the gravel and the filter walls is placed before the first layer. The first two layers are each brought approximately level before the next one is added and are settled with water. The top layer is brought to a true and even grade and the surface left smooth and uniform.

Arrangement of Filters.—The filters are almost symmetrically grouped on both sides of a 16-ft. roadway, with parkings on each side, that is provided over the 60-in. rising main of the Allegheny water-works that extends through the site. They are in eight rows transverse to this drive, with a covered pipe gallery 31 ft. wide in the clear between each alternate row of filters, or four galleries in all. These galleries are approximately 1,000 ft. long, with the exception of the one at one end, and are divided in half transversely by the roadway over the 60-in. rising main. They have the same type of construction as the filters, with which they are built continuously, and have three longitudinal rows of bays. All piping, wiring connections, gates, regulating and registering apparatus for the filters are placed in these galleries and the auxiliary apparatus and machinery used in the operation of the filters will be located or stored in them. The entrance to the filters is from the galleries and all sand washing will be done in them. No storage space for dirty or for washed sand is provided in them, however, as with the system of sand scraping, washing and restoring that has been adopted for the plant no such space is necessary. The air in the galleries will be maintained at a minimum temperature of about 50° Fahr. by a fan and heater system in each gallery so that operations can be carried on without reference to the outside temperature.

Each half gallery serves six beds, three on each side, with the exception of one-half of the short gallery at one end, which half serves four beds only. The arrangement of the galleries and of the piping connections and all apparatus in them is practically the same in all four. The central bay has a clear height of 14.5 ft. to the springing line of the roof arches. A mezzanine floor built over this bay 9.5 ft. above the main floor serves as a platform from which the operation of the filters may be controlled. This floor is carried by reinforced-concrete beams placed longitudinally between the two rows of piers carrying the roof arches. It consists of independent concrete slabs, 3 ft. wide, which simply rest on the beams between the piers and may be lifted out, thus providing a clear space between the two longitudinal rows of piers in the gallery.

One of the four branches from the conduits conveying settled water from the sedimentation basins extends the length of each gallery. This settled-water supply main is of riveted steel and varies from 60 in. in diameter at the inlet end to 30 in. in diameter at the outlet end. It is placed under the mezzanine floor on concrete pedestals, spaced 7.5 ft. apart on centers. These pedestals are made in two blocks, one a cradle on which the pipe rests and the other a rectangular block placed vertically on end which carries the cradle. The ends of the rectangular block are rounded to the arcs of a flat circle and permit the block to rock slightly as the pipe is moved by expansion and contraction. Two expansion joints are also placed in this line in each half gallery to allow for movement due to changes in temperature.

The connection from the settled-water main supplying each filter is made through a 20-in. pipe in the corner of the filter on the gallery side nearest the sedimentation basins. The connections for two filters are made at the same point and beyond each pair of these connections the size of the settled water main is reduced. The piping con-


Note:-Ventilator shaft is to be built in conjunction with filter roof.
Ventilator Covers.
Top Soil.
1 cu. ft. Gravel, per linear foot.
Filling over vaulting.
6"×6" Brass Screen ⅛" mesh over each Drain.
Parabola
Ellipse
2" Drain spaced every 30 feet.
Approximate Water Line
2" Tile Drain.
13'-2"
15'-0"
268'-2"
Maximum Sand Line
Concrete Gallery Wall
Concrete Pier
Note:-⅜" steel rods, 18" c. to c. both vertical and horizontal. 1½" from faces of wall. Horizontal rods not to cross expansion joints.
Manhole
Main Effluent Collector.
Gravel Line.
Circle
No wall of this type to be built at present.
R6'-7"
Future Dividing Wall
SECTION THROUGH CROWN OF ARCH.
Scale
0 2' 4' 6'
2'-10"
14"
SECTION OF PIER.
Filling over vaulting.
1 cu. ft. Gravel per linear foot.
2" Drain, spaced every 30 feet.
Dividing Wall.
Gravel Line.
Parabola.
Ellipse.
1 cu. ft. Gravel over each Pier.
Large pieces of gravel to be placed about opening.
Approximate Water Line.
2" Tile Drain.
Special Tile Pipe
Maximum Sand Line.
165'-2"
Pier.
Main Effluent Collector
Special 4"×6" C.I. Reducer
Brick.
6"×6" Brass Screen, ⅛" mesh over each Drain.
Circle
Embankment. Class B.
R6'-7"
All piers in the first and second rows from a wall shall have a key as shown here.
6'-0"
Parabola
Regular Outside Wall.
Slope 3 to 1.
3'-6"
SECTION THROUGH PIERS.
Scale
0 2' 4' 6'
Standard C.I. Class D. ⅛ Bend Straight piece cut to fit.
Note:-The distance of center line below filter floor varies; the minimum is 15" as shown, the maximum is 20."
4'-3"
Manhole
8'-5"
PLAN AND SECTION OF OUTLET FROM MAIN EFFLUENT COLLECTOR FOR FILTERS ON THE WEST SIDE OF GALLERIES.
SECTION SHOWING METHOD OF SETTING FASTENERS ON ROOF CENTERS.

Detail Section Through Filters and Plan and Section of Outlet from Main Effluent Collector.

nections and methods of introducing and regulating the flow of water and of sand washing are practically the same for all the filters. The flow in the 20-in. influent connection to each filter is controlled by a float on the stem of a valve in a 6-ft. 9-in. by 9-ft. 6-in. concrete well in the inlet-corner of the bed. The tops of the walls of this well are at the minimum sand surface level in the bed, and when the sand is above that level they are carried up to the surface of the sand with bricks laid up dry. The controlling valve on the influent pipe is of the disk type, the water entering it at the side and flowing out both top and bottom. The float on the stem of this valve rests on the surface of the water over the sand in the filter and within certain limits may be set at any desired height, which height determines the depth of water over the sand.

From the inlet well the water passes into the bed, down through the sand and gravel and into an underdrainage system leading to an affluent outlet. This underdrainage system consists of a reinforced-concrete main collector extending the length of the filter in the longitudinal center bay. A lateral drain in each transverse bay leads to the main collector. The ends of these lateral drains are 6 ft. from the side walls of the filter and have perforated covers. The first 40 ft. of each lateral drain from the wall end is of circular 6-in. vitrified terra-cotta pipe and the remainder, halves of 12-in. vitrified terra-cotta pipe. The sections of pipe are laid with open joints and an 18-in. special shape forms the connection between the two different sections.

The main collector connects with a reducer in the wall at the outlet end of the filter which joins it to a 20-in. cast-iron pipe leading to a reinforced-concrete chamber in the gallery in which the outlet regulating valve is located. The chamber has parallel sides 42 in. apart and round ends built on a 21-in. inside radius, with a total inside length of 10.75 ft. Each chamber is built on the floor of the gallery in one of the side bays and extends 38 in. above the mezzanine operating floor over the central bay. The 20-in. pipe connecting the main underdrain collector of each filter with the regulating chamber of the latter passes into the chamber at one end near the bottom and extends to the middle of the chamber where it ends in a piston orifice valve. This valve is set vertically and has three horizontal rows of ports which are controlled by a piston mounted on a valve stem extending up to the top of the chamber. Two copper floats resting on the surface of the water are attached to this stem and move the latter up and down as the water level varies due to the increasing loss of head in the filter. By adjusting the position of these floats and of a circular weir on the outlet pipe, the rate of flow from the filter may be accurately fixed and maintained. The outlet from the regulating chamber is a 20-in. pipe set into the side of the chamber. This outlet pipe connects with an elbow, one leg of which is vertical and is directly centered over the control valve. The circular weir is also attached to a frame on the two floats and is moved up and down in the top of the vertical leg of the elbow on the outlet pipe by the floats. The rate of flow over this weir is controlled by fixing the distance between the top of the weir and the top of the floats by a hand-wheel adjustment on the valve stem standard set up on top the chamber. This standard also carries an indicating scale on which a pointer attached to the valve stem shows the rate of filtration. The top of the elbow is set so the maximum rate of flow obtainable through it is equal to a rate of filtration of 3,000,000 gal. per acre per 24 hr. for the filter.

The limited head room available in the galleries required a valve whose stem would travel only small vertical distances, necessitating the water level in the outlet regulating chamber to be maintained at a practically constant level. This valve fully meets this requirement as the vertical travel of its stem is only a few inches. At the same time it is considered to be as accurate as any type of effluent regulating valve that has been built.

A recording gauge indicating the rate of filtration, the loss of head and the depth of water over the sand is supplied for each filter. This gauge records automatically the rate of filtration, the height of water in the filter and in the regulating chamber, and from the two latter records the loss of head may be read at a glance. The two gauges for each pair of filters are placed together on the same side of the mezzanine floor over the central bay. A gauge which indicates the height of water in the filter during refilling is placed with each pair of recording gauges and serves two filters.

The regulating chambers for all of the filters served by a gallery are placed in pairs on the same side bay of the latter, each two opposite filters being paired together. A 20-in. pipe for refilling the filters through the underdrains after their sand surfaces have been cleaned is connected to the effluent pipe of each of the filters in a gallery and the refilling is done with water from an adjacent filter. The effluent pipe of each filter is also connected with an egg-shaped drain that extends the length of the gallery in such a manner that the flow from a filter may be wasted when desired.

Sand Washer Tank in Gallery.

The 20-in. outlet pipe from the regulating chamber connects with a filtered-water main of riveted-steel pipe which is placed longitudinally directly under the pedestals carrying settled-water main and under the floor of the central bay of the gallery. This filtered-water main varies from 30 in. in diameter at the point where the first two of the twelve filters in each gallery are connected with it to 60 in. at the end of the gallery. This main and an egg-shaped drain in each gallery built of concrete are the only parts of the piping placed below the floor. Manholes in both of them at frequent intervals, however, permit them to be entered readily from the gallery.

A room is placed in each gallery for the attendant in charge of that gallery and the filters connected with it. Telephone connections are made between each of these rooms and the superintendent's office in the administration building, in order that the latter may be in close touch with the entire plant. A specially designed patrol box is placed in the gallery in front of each filter and all samples of filtered water for analysis are obtained from taps in these boxes. The insertion of the key which opens the boxes automatically registers in the superintendent's office the time of opening, thus preventing interpolation of records by the sample collectors.

Toilet rooms for the attendants and laborers required in operating the filters are provided in each half gallery. A locker room is provided in one of the galleries and a lunch room will also be built. These rooms all have tight floors at the level of the mezzanine floor in the gallery. The toilet and locker rooms are enclosed and these rooms and the lunch room are so arranged that they may be readily cleaned.

The ventilation of each gallery is accomplished by an 8-ft. Sturtevant fan driven by a 35-h.-p. motor. This fan is placed near the entrance to the north half of the gallery from the drive over the 60-in. Allegheny water main and receives its air supply from the outside through a 5.5-ft. circular opening in the roof of the gallery. The incoming air in the winter is drawn over a system of heating pipe coils supplied through an underground pipe with live steam from the pumping station. The fan has two exhaust outlets, one of which opens directly into the half gallery in which the fan is located and the other connects with a duct built of concrete that is laid under the 60-in. Allegheny water main and opens in the other half gallery. This fan will supply air to ventilate the gallery at such times when the doors in the end walls of each half gallery cannot be left open. It is also expected that the heater system will be of sufficient capacity to keep the temperature in the gallery at about 50 deg. Fahr. during the coldest weather.

The only entrance to each filter from the gallery is a 5.25x7-ft. opening at the level of the mezzanine floor in the gallery. This opening is below the level of the water in the filter and will be closed by a hydraulically-operated sluice gate. The covers to the filters have only thirteen ventilators to each acre bed and under normal operating conditions these will be closed. When a filter is to be cleaned the sluice gate controlling the entrance to the gallery will be opened after the water has been drawn down and the ventilators in the covers opened. The humidity in the filter will then be reduced as much as possible, and during cold weather the temperature raised by the ventilating fan and heating system.

Sand Scraping, Washing, and Restoring.—The most unique features of the entire plant are the machines that are to be used in removing dirty sand from the filters and in replacing clean sand after the surface of the sand bed has been lowered by scraping. These machines were invented by the Blaisdell Filtration Co., of Los Angeles, Cal., and have been especially developed to meet the requirements of this plant. The first of these machines will remove from the surface of the sand in the filter a layer from ¼-in. up to any practicable thickness desired of the fouled surface sand, after the water has been drawn down 10 in. below the surface of the bed, and leave the remaining sand perfectly smooth and undisturbed. The sand is then delivered by a hydraulic ejector of the usual type to a system of pipes in which it is hydraulically transported out of the filter being cleaned to a sand washer in the gallery and thence through pipes in which it may be transported to any other filter in the plant. The second of these machines receives the clean sand and the water by which it is transported, and after separating the water from the sand, restores the latter to the filter and spreads it over the surface of the same, without stratification, to any desired depth and diverts the dirty water into a drain.

Although the installation of these machines in this plant is the first case in which they have ever been adopted on a large scale, they have both been thoroughly tested and have fully and conclusively demonstrated their practicability in actual service. A demonstrating station was erected by the company on the bank of the Allegheny River near the Brilliant pumping station of the city water works and was operated for a year to show the feasibility of the machines. This station adjoins the small slow-sand and mechanical filters on which the experiments when treating Allegheny River water were made that largely determined the choice of a slow-sand filter plant for the city of Pittsburgh and also the general features of that plant.

This demonstrating station consists essentially of a slow-sand filter having the same width and clearances as one of the bays of the filters in the filtration plant that is being built by the city. In this station Allegheny River water was filtered, without sedimentation, for nearly a year. The surface of this filter was scraped when necessary with the scraping machine and the sand replaced by the restoring machine after the minimum depth had been reached. Analyses were made of the raw and filtered water at this station by the representatives of the city. The results of this long trial run when compared with the results obtained in the operation of the experimental slow-sand filter previously operated by the city showed that the use of the scraping and restoring machines had no detrimental effect whatever on the efficiency of the filter, and furthermore that the machines could be utilized successfully to effect economies in operation.

Interior of Filter Showing Piping and Track System.

The filters of the plant that is being built by the city were designed to be operated with or without the sand-scraping and restoring machines. A few details of design, therefore, are not just what would be used if the filters had been previously planned solely for the operation of the mechanical sand-scraping and restoring apparatus. For that reason the machines that will be used in this plant are not in some mechanical details as they would be built where the construction of the filters is made to meet their requirements.

Sand-Scraping Machine.—The scraping machine consists essentially of a sand-scraping apparatus carried by a traveling bridge, or crane, which spans a bay of the filter and runs on a 12-ft. gauge track consisting of a rail on each side of the bay. These rails are carried on brackets secured to the piers which support the groined arches of the covers. A track extends the length of each longitudinal bay, except across a transverse bay near the center line of the filter in which a transfer table carrying a track is placed. With this arrangement the machine can be brought in on a track in the longitudinal bay leading from the sluice-gate entrance at the gallery end of the filter and transferred to the track in any other longitudinal bay.

The traveling bridge that carries the scraping apparatus consists of a rectangular frame built up of structural-steel shapes. This frame is carried at each corner by a double-flanged wheel, the wheels running in pairs on the two rails of the track in each bay. It is propelled forward and backward along the rails by a 2-h.-p. motor geared to a shaft to which the drive wheels are geared. The driving gear is arranged so that four speeds forward, varying from 2 to 10 ft. a minute, and a reverse speed of 50 ft. a minute, may be secured.

The sand-scraping apparatus is carried by a lower frame balanced on a short trunnion bearing on each side of the upper frame or traveling bridge. This apparatus consists, briefly, of two spiral conveyors, or scrapers, 16 in. diameter, which remove the sand from the surface of the bed and deliver it to an inclined bucket elevator that discharges at the top into the hopper of the hydraulic ejector by which the sand is placed in the transporting system of pipes leading out of the filter. The two spiral conveyors are placed transversely to the direction of travel of the machine, and toward the front on each side of the center of the latter, one being a right-hand and the other a left-hand spiral.

Directly in front of these scrapers is a broad sheet-steel shoe, which is placed parallel to the scrapers and rests on the surface of the sand. This shoe is attached to two vertical guides on the lower frame of the machine and is so arranged that its vertical position is easily changed and the depth of cut made by the scrapers thus regulated. The unbalanced weight of the machine that is carried through the shoe on the surface of the sand is sufficient to cause the scrapers to follow closely any undulations in that surface.

The two 16-in. spiral conveyors will cover the portion of the bay outside the outer lines of the piers. In order to completely cover the balance of the space between the side lines of the piers in each row, an auxiliary 10-in. spiral conveyor is placed on the machine in front of each of the main conveyors. These auxiliary conveyors are so arranged that when the machine reaches a pier they are automatically drawn toward the center of the machine and clear the pier. As soon as the pier is passed they are immediately extended, automatically, about 1 in. beyond the center line of the pier.

The automatic device which controls the transverse movement of these auxiliary conveyors consists of a hydraulic piston valve in which an unbalanced pressure exists that normally holds the conveyors extended. A frame carrying three small wheels in the same horizontal plane is set out on each side of the lower frame and causes the pressure to be reversed automatically and the conveyor drawn in when a pier is reached. This frame is so connected to the operating mechanism of the valve, and the three wheels are so placed on it that the auxiliary conveyors are drawn in when a pier is reached whether the machine is going forward or backward. A device is also provided whereby the auxiliary conveyors may be held in a single position by the operator.

The bucket elevator to which the scrapers deliver the sand that has been removed from the surface of the bed is driven by a 3-h.-p. motor. This motor also drives all of the conveyors through shafts connected with the driving shaft of the elevator. The latter raises the sand to the top of the machine and discharges it into the hopper with a hydraulic ejector in the bottom. This ejector has a ¾-in. nozzle and a 1⅜-in. throat and is supplied with water from a piping system under 100-lb. pressure through a hose connection with the supply line. It has a capacity of 15 cu. yd. an hour, which limits the capacity of the scraping machine to that amount.

The trunnion bearings which carry the lower frame of the machine are each carried by a crosshead that operates in a compound vertical guide. These crossheads are attached to a raising and lowering mechanism operated by a hand wheel and through them the lower frame can be moved through a vertical travel of a little over 4 ft.

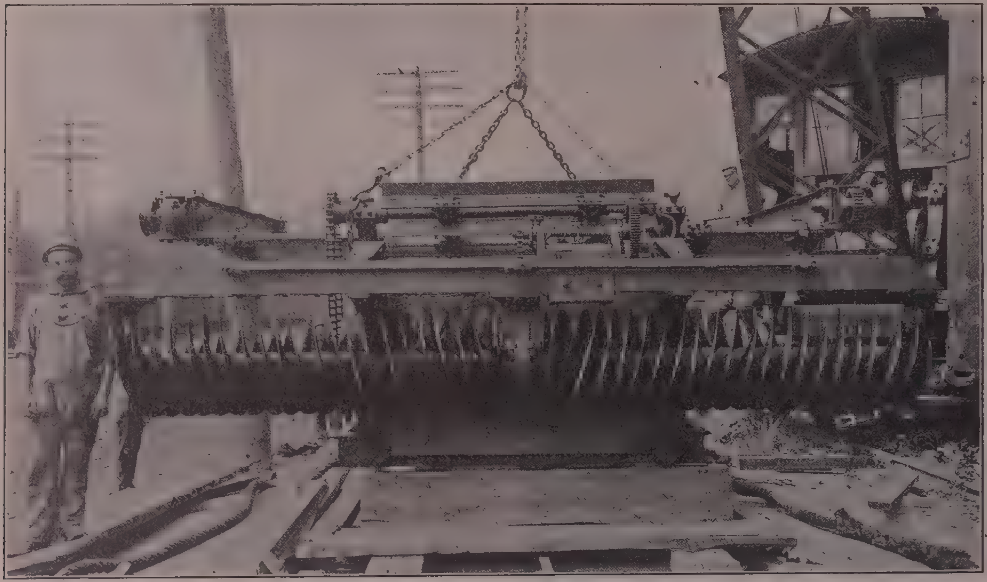
The maximum sand level in the filters is 48 in. above the top of the gravel on the bottom of the bed, and the minimum sand level will be 2 ft. above that level. The machines are so arranged that the scraping apparatus will readily clear the maximum sand level and also so the sand can be removed by them clear down to the gravel.

Each machine is operated entirely by one man, who stands on a running board suspended across the rear of the machine. The various switches and levers controlling the motors and the parts of the machine driven by them are all in easy reach from this running board. The hand wheels operating adjustments of the machine are also placed so they can be turned easily by a man on the running board. The machine, the motors driving it, and all of its parts are built so that no amount of moisture in the filter will interfere with their operation. The machine is also built so an inexperienced operator cannot injure it in any way by wrong manipulation of switches or controlling levers.

Sand Transporting and Washing System.—The pressure system through which water is supplied to the hydraulic ejector on each scraping machine consists of a 12-in. supply pipe in each gallery reducing to an 8-in. pipe at the ends of the gallery. A 6-in. connection from this supply pipe is extended, suspended from the roof, into each filter to the transverse bay next to the one in which the transfer table is located. A 5-in. branch is carried in both directions in this bay to the side bays of the filter. At each alternate pier in this transverse bay a 5x5x3-in. tee is inserted in these 5-in. branches in order that hose connections may be made between the scraping machines and the pressure line.

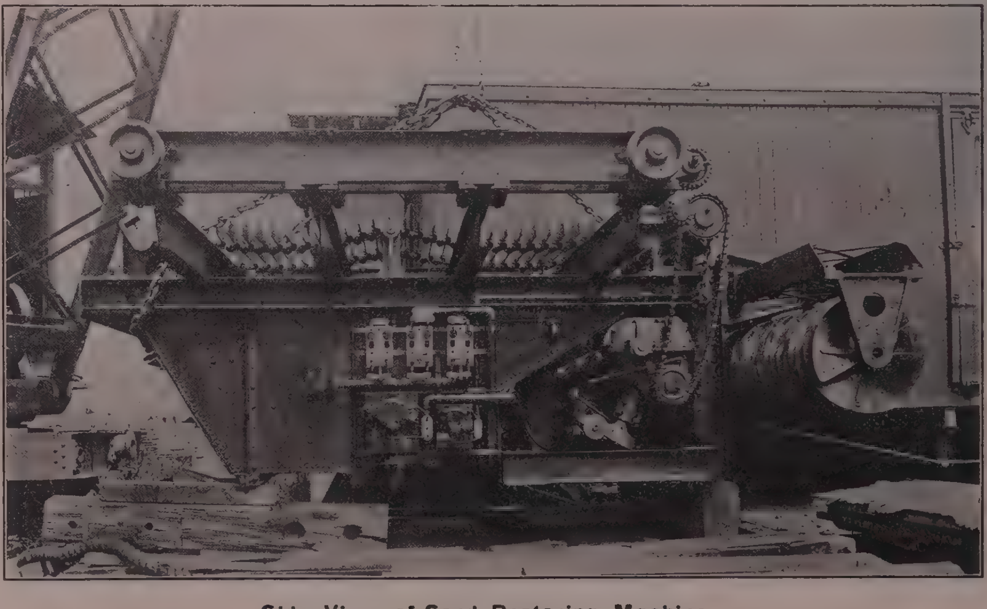
The discharge from the ejector on the sand-scraping machine is connected through a 3-in. rubber-lined hose with the system of sand transporting pipes. Six 3-in. pipes are extended into each filter along with the 6-in. pressure line to the transverse bay in which the branch lines from the latter are hung. Four 3-in. pipes are extended in this transverse bay to both side bays of the filter, two of the four pipes leading to each side being connected with two of the six 3-in. pipes from the entrance to the filter. The other two of each four cross pipes can be connected to the two remaining pipes from the entrance with flexible hose connections. The 3-in. pipes in the transverse bay are tapped at each alternate pier in that bay with special long sweep tees for a hose connection with the discharge of the ejector.

The 3-in. pipes into which the ejectors discharge extend to a sand-washing tank built of concrete in the gallery, two of which tanks are placed in each half gallery. These tanks are placed in the opposite side bay from the regulating chambers of the filters and have their floors level with the mezzanine floor over the central gallery. They are approximately 10.5x50 ft. in plan and 4.75 ft. deep, and each contain six sand-washer hoppers with hydraulic ejectors in the bottom. The six 3-in. sand-carrying lines from each filter are connected with a system of piping in the gallery by interchangeable flexible hose connections so that sand from any filter can be transported to any washer and from any washer to any filter. The gallery pipes are connected by flexible hose connections to stilling boxes over the sand-washer hoppers. The latter are placed in a chamber, 6 ft. 9 in x 34 ft. 1 in. in plan, at one side and one end of the tank, which is separated from the balance of the tank by concrete walls. A space 3 ft. 4 in. wide remains between the inner side of this chamber and the side of the tank and forms a trough into which the dirty water from the hoppers is discharged. The sand will be washed in the hoppers in the chamber. The hoppers are built so the top of the side next to the trough is lower than the other sides and extends out over the wall separating the trough from the chamber. This trough connects with a 10x10.5-ft. settling compartment in the end of the tank, the outlet from which is over a weir formed by stop planks in the corner of the tank. Any sand of value that is carried over from the hoppers will be intercepted in this compartment. This sand can be shoveled up on a platform at the end of the chamber containing the hoppers, and from that platform into the latter. The flow of dirty water over the outlet weir passes directly into the drain under the floor of the gallery.



Front View of Sand Restoring Machine.

A 6-in. connection with the high-pressure system is laid in the washer chamber and is connected to the hydraulic ejector in the bottom of each hopper. The discharge from these ejectors is connected by flexible hose with the system of sand-carrying pipes in each gallery. The systems of these pipes in the various galleries are connected together so that sand may be delivered from any washer to any filter in the plant. The usual method of operation, however, will doubtless be to operate the twelve filters on each gallery as a unit, under which conditions it will never be necessary to transport sand more than 500 ft.



Side View of Sand Restoring Machine.

The sand-carrying lines leading from the washer tanks will deliver directly to a sand-restoring machine in one of the filters. With this arrangement no sand storage space is required and none has been provided.

Sand-Restoring Machine.—The machine that has been adopted for restoring sand is also carried on a traveling bridge that runs on the same rails that carry the sand-scraping machine. Suspended from this traveling bridge is a sheet-steel tank and a lower frame carrying part of the apparatus used in the restoring, the motors driving the various parts of the machine and the sand-leveling devices. The clean sand is carried to the restoring machines from the washer tanks in the galleries through the same 3-in. lines in which the dirty sand is carried from the scraping machines. These pipes are connected by a 3-in. hose with a stilling chamber on the top of the rear end of the tank of the restoring machine. The rear end of this tank is inclined toward the front from the vertical at an angle of about 30 deg., while the front end of the tank is inclined at an angle of about 30 deg. with the horizontal and only a short portion of the bottom is horizontal. The tank has a depth of 3 ft. 2 in. over the horizontal portion of the bottom, is 9.75 ft. long and 5 ft. wide. The tank and the lower frame are centered on the traveling bridge. A flight conveyor on endless link belts extends the width of the tank and moves the sand through the latter. This conveyor travels down parallel to the rear end of the tank, inside the latter, along the short horizontal bottom, up the flat slope of the front end and thence nearly horizontally over above the top and back to the rear end of the tank.

The stilling chamber at the top of the back end of the tank extends the full width of the latter and in it the pressure on the two sand-transporting hose connections to each restoring machine will be throttled. The outlet from this stilling chamber is an adjustable horizontal orifice which extends the width of the tank. The travel of the conveyor parallel to the inclined rear end of the tank is in a space about 10 in. wide between the rear end of the tank and a baffle plate parallel to the latter. The orifice outlet of the stilling chamber discharges into this space, the baffle plate extending to within 1 ft. of the bottom. At the lower end of this baffle plate the water and such mud as may be in it separate from the sand, rise to the surface, which is kept about 2 ft. 4 in. above the bottom and 9 in. below the top of the tank by an overflow pipe. This pipe is placed transversely across the tank in front of the baffle plate at the rear and has an adjustable orifice in the top through which the water enters it. It connects with a 4-in. centrifugal pump mounted on the lower frame of the machine under the inclined rear end of the tank. This pump discharges through a hose connection with a 10-in. drain that is laid in one of the transverse bays and connects with the drain in the gallery.

The flight conveyor pushes the sand along the bottom and up the inclined front end of the tank and then out over the end on the sand on the surface of the filter. The bottom and inclined front of the tank are lined with maple plank, which are so fastened as to be easily removed, in order to relieve the plates of the tank of all wear due to the movement of sand. The point where the sand is discharged from the tank is about 9 in. vertically above the surface of the water in the tank and 20 in. along the inclined end from that surface so that the greater part of the water is drained from the sand before it drops on the filter.

The sand is spread on the surface of the filter by two spiral conveyors, a right and a left-hand one, carried on a frame at the front of the tank.

These conveyors are placed transverse to the travel of the machine and spread the sand from the center of the machine to sides of the bay, in the opposite manner from which the spiral screw on the scraping machines carry the dirty sand toward the center of that machine. These spiral spreading screws have a 2-in. clearance between the piers on each side of a bay. A vertical plate at each end covers a little more than half the space between the outside lines of each row of piers which the spreading screws do not reach. When the machine reaches a pier these plates are automatically drawn in until the pier is passed and are then automatically pushed out in place again.

Sand can be restored to two levels, by this machine the top of the first restoring level being 2.5 ft. above the maximum gravel line and the top of the second level 4 ft. 3 in. above that line, allowance being made for settlement in both cases. The lower frame of the machine has a 1¾-in. clearance over the first restoring level and is fixed in its vertical position. The machine works crab fashion, the sand being brought up above the lower frame in front of it to reach the second restoring level. The frame on which the spreading screws are mounted is on vertical guides on the front of the machine and can be set at two positions, one for the first restoring level and the other for the second level.

The spreading screws, flight conveyor, and traveling bridge are driven by motors mounted on the lower frame of the machine. The speed of the machine when traveling in the direction in which sand is being restored is regulated through a controller having eight speeds varying from ½ to 1 ft. a minute. The travel of the machine can be reversed and a speed of 25 ft. a minute secured in that direction.

The centrifugal pump on the machine operates against a total head of 50 ft. and delivers 500 gal. a minute. All of the operating functions of the machine are controlled from a panel on one side of the latter. The operator of the machine walks along beside the latter ahead of the layer of restored sand.

The motors on the machine are supplied with electric power from a system of wiring suspended from the roof of each filter. The main feeder wires for each filter extend from a switch box in the gallery to the transverse bay in which the cross pipes of the sand-transporting systems are located and thence to both sides of the filter in this bay. A receptacle in which cable leads can be inserted and connected is placed in the same bays in which hose connections are made.

Twelve of the sand-scraping and six of the sand-restoring machines will be purchased to be used in connection with the forty-six filters. The present plan is to use three scraping machines simultaneously when scraping a filter. Each of these machines will be operated by one man with about two helpers to the three machines. Based on the results secured in the demonstrating station it is believed that one of the acre filters can be scraped and the sand placed in another filter by the restoring machines in 4 hours. The reduction in cost in the operation of the entire plant due to the mechanical sand scraping and restoring as compared with the usual method of doing this work by hand is estimated to be about $25,000 per year, making all allowances for investment in equipment and apparatus.

(To be continued.)

THE 60,000-VOLT TRANSMISSION LINE of the Edison Electric Co. of Los Angeles is now practically finished. It runs from a 25,000-h.-p. hydro-electric station on the Kern River a distance of 125 miles to Los Angeles, and consists of six cables carried on steel towers from 30 to 75 ft. high, and furnished with insulators weighing 50 lb. apiece, and about 3 ft. high.

Notes on the Fabrication of the Quebec Bridge.

The spans of the 40,000-ton Quebec bridge are so long and the loads carried are so great that the dimensions and the weights of the truss members greatly exceed ordinary practice and require special care and great accuracy in their construction at the bridge shops. The anchor and main spans of 500 and 1,800 ft. respectively, are 315 ft. deep and are divided into 50-ft. and 56-ft. panels with their principal members varying from 50 ft. to over 100 ft. in length, and having maximum weights of over 100 tons. Many of the compression members are thus longer and heavier than single-track railroad plate girder bridges of ordinary span. They are built separately at the bridge shops and are seldom assembled or connected together until finally erected in the permanent structure where they are handled by the traveler hundreds of feet above the water, exposed to severe storms and under conditions where it is imperative that they should fit with extreme accuracy and engage together with absolute facility and precision.

It is therefore evident that great perfection of work must be attained and verified at the shops not only to insure safety and rapidity in the limited periods during which the erection can be carried on in a short northern summer, but also to provide for the proper transmission of the enormous working stresses, which are as much as 16,000,000 lb. in some members. In general the shop work is done by the standard methods and machine tools provided for regular service on all the miscellaneous heavy work executed at the Phoenix bridge shops and the methods of handling and fabricating the great members correspond to those in ordinary practice. Some features are, however, modified in accordance with the unusual dimensions of the work, and it is of interest to note what provisions are taken to insure precision and to inspect the work in progress and finished members.

The structure contains about 3,000 eye-bars weighing altogether 7,500 tons. They include almost the largest dimensions yet manufactured, namely 15 x 2 1/16 in. by 76 ft. long, with heads 36 in., wide bored for 12 and 14-in. pins. They are made from medium, open-hearth steel of an average ultimate strength of 63,000 lb. per square inch, and are proportioned for maximum working stresses of about 22,000 lb. per square inch. Great care is taken in selecting the steel for them which is made from slabs rolled only from the soundest parts of special ingots. Three tensile and three bending specimens are taken from each heat and are tested for the acceptance of the blanks from which the eye-bars were forged. After careful surface inspection, the eye-bars are upset in three heats by a hydraulic machine and are die-forged in three more heats by a 12,000-lb. steam hammer which finishes the comparatively thin heads with an excess of about 40 to 45 per cent. of the net cross-sectional area above that of the body of the bar. Great pains are taken to make uniform heads with a thickness not exceeding the thickness of the body of the bar by more than 1/16 in., and they are hammered until black, thus working the metal sufficiently to develop the required strength in the forged portions.

The sizes of the heads are checked by measurements at right angles to the axis and diagonal to it, and they are tested for alignment and to verify the center of the head in the axis of the bar. The surface is also tested by a straight edge to detect any dishing in the face. The lateral dimensions of the heads are not allowed to vary more than ⅛ in. from the drawings on account of the close packing and small clearances which are provided in the field connections.

The bars are supported continuously in a horizontal position and the holes in them are laid out by standardized, 100-ft., steel tapes, with spring balances uniformly stressed with a 12-lb. tension. Measurements are taken from back to back of the pin holes and are made to 1/64 in., a degree of accuracy well within the variations which would obtain under the most careful measurements if the spring tension were omitted. The holes are first hot punched in approximate position to a reduced diameter, when the heads are forged and are afterwards counterbored with two rough cuts and one finishing cut, in vertical boring machines.

The holes are bored 3/64 in. larger than the diameter of the pins, and their size is tested by a cast-iron disc gauge with exactly the required diameter so that it fits tightly in the pin hole and will drop through it if the latter is more than 1/100 in. too large. Both the position and size of the holes have been found extremely accurate, and in the only instance in which an important error was discovered it was remedied by reboring the set of bars and post at the same connection for a larger pin. The pin holes are inspected for piping or other defects that might develop in the metal and are then covered as usual with white lead and tallow to protect the finished surfaces until they are erected.

The pins which have diameters and lengths up to 14 in. and about 10 ft. respectively, are turned, bored through the axis for the 1¾-in. tie bolt and have their ends shouldered and threaded for pilot nuts. The latter are screwed on and the pins are inspected and tested by a circular gauge with its diameter 0.006 in. larger than that of the pin, thus checking the size of the pin and verifying the centering of the pin and the pilot.

Great care is taken to secure perfectly matched field rivet holes in the splices of the bottom chords vertical and diagonal posts. They are accurately drilled in the members themselves and in the splice plates by means of wrought-iron templates 2 in. thick which are numbered and marked for the respective joints and are adjusted in line and position with extreme accuracy, and firmly clamped to position before the holes are drilled. Some of the heaviest work in the bridge is required for the 1,350-ton vertical transverse bent over the main pier. Each post is built in seven principal pieces, one of them weighing 112 tons, and all are spliced together with field-riveted joints involving a large number of rivet holes which were drilled with great care and were found to match closely when assembled for the first time in the field. The lower sections or feet of the vertical posts are bored for 24-in. pins, nearly 7 ft. long, which weigh 10,000 lb. each and are larger than any previously used in bridge construction. These pins take bearing in riveted pedestals with ribs from 6 to 13 in. wide.

The bottom chord pieces are made in single panel sections 50 ft. and upwards in length with rectangular cross-sections 4½ ft. deep and 5½ ft. wide made with four built channels with 8x6-in. flange angles. They have a maximum cross-section of 842 sq. in., being proportioned for a total working stress of 16,000,000 lb., and weigh up to 100 tons each. Building these enormous members was a difficult matter. The different webs with their flanges and reinforcement plates were first assembled, reamed and riveted and then assembled together to make the complete member, great care being taken to keep the webs straight and parallel and out of wind. Spacing blocks were placed between them and they were securely held in position by heavy clamps and diagonal hook rods adjusted by powerful turnbuckles.

Rivets are mostly driven by movable pneumatic yoke machines, but many of them are inaccessible for these machines, and are driven with pneumatic hammers, much skill and ingenuity being required to reach some that are in difficult positions. Ordinary bridge shop tools, modified and adjusted as found necessary, are used to reach bolts and rivets in apparently inaccessible places. Where several thicknesses of very heavy angles and plates are riveted together, special pains are taken to draw them up tight and avoid any spreading, and remarkable success has been attained in the accuracy of the work done and in providing the required clearances.

The provision of separate pins in the vertical posts at all panel points for the connections of the chords and diagonal bars, is a notable feature of the design and involved very unusual construction in the vertical posts. They are made with several wide transverse diaphragms at the top, bottom and middle points, each of them bored with two large pin holes, one or both eccentric from the axis of the post. These diaphragms are in some cases 10 or 12 ft. long and wide making the posts bulky and difficult to handle. The location of the pin holes in them is difficult, requiring great skill and accuracy.

They are laid off and checked from center to center, or from center to the faced end of the member and special care is taken in boring them to have the members perfectly aligned and in horizontal planes exactly perpendicular to the axis of the boring bar. A very slight deviation in the latter respect having much more serious results for a lower chord piece 5½ ft wide than would be the case for an ordinary section 2 or 3 ft. wide. In the case of the largest members, some of the pin holes are laid out by a transit, the use of which is found very advantageous.

The holes are laid out on both sides of the members and care is taken to check the boring so that it exactly corresponds with the marks on the opposite faces of the member. The positions of the holes are checked and the distances apart on centers are measured by the aid of discs 2 in. in diameter, each of which is provided with three set screws by which it can be quickly adjusted in the pin hole and the exact center located on it. For lengths of about 10 ft., the distances between pin holes are measured by a trammell. Longer distances are measured with the 50-ft. and 100-ft. spring gauge steel tapes, stressed to the uniform tension of 12 lb. In some cases where two pin holes not in the same plane are to be laid out and measured, wooden supports about 4 ft. apart are erected to carry the tape. By such methods and the use of straight edges, all pin centers are checked to 1/64 in. All pin holes in riveted members are tested by a cast-iron gauge about 6 ft. long turned to the same diameter as the finished pin.

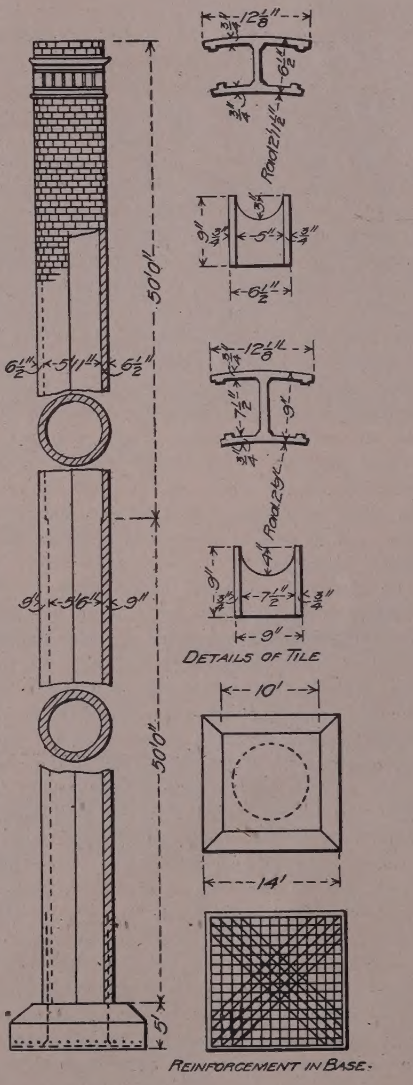
The members are handled in the bridge shop by the traveling cranes of 200,000 lb. capacity used for the regular shop work and when finished are loaded on standard gauge platform cars and delivered from the shops to the adjacent yards where they are unloaded by electric traveling cranes of 90 ft. span and 100 tons capacity, which have tracks of an aggregate length of about 400 ft. Between these tracks the members are stored in piles reaching nearly to the train tracks.

About 16,800 tons of material have already been shipped to the site, and 14,500 tons more are now in storage at the bridge shops. Some of the members which are intended for the north anchor arm have been completed long in advance of the time when they can be shipped, and special pains are taken to inspect them from time to time and keep them thoroughly painted.

A large proportion of the steel for this bridge, except the plates and pins, is rolled by the Phoenix Iron Mills adjacent to the bridge shops, and a complete system of inspection of materials and workmanship is maintained by the contractors besides that which is conducted by Mr. E. L. Edwards, chief inspector for the Quebec Bridge Co. Mr. Theodore Cooper is the consulting engineer, Mr. E. A. Hoare is chief engineer, and the contract for the steelwork and erection is held by the Phoenix Bridge Co., Mr. John Sterling Deans, chief engineer.

A New Type of Reinforced-Concrete Chimney.

A reinforced concrete chimney which differs radically in construction from the usual steel-concrete stack is that of the Dering Coal Co., of Witt, Ill. This stack was built according to the Wiederholt system. It is 100 ft. high and has a uniform outside diameter of 7 ft. The lower 50 ft. of this wall is 9 in. thick and the upper 50 ft. is 6.5 in. The foundation is a concrete monolith 14 ft. square and 5 ft. deep. The chimney is attached to it by vertical steel rods embedded in the concrete of both wall and base.



Details of Concrete and Tile Chimney.

In the Wiederholt system of construction a thin shell of fireclay tiles is made to act, first, as a mold for the wet concrete and, second, as a permanent lining and surfacing. The tiles are so shaped as to permit the use of both vertical and horizontal reinforcing bars. In horizontal section the tiles have somewhat the shape of the letter H. The sides of the H are rectangular slabs which form the two surfaces of the completed wall. The cross bar is simply a web to hold the sides while the concrete is being placed. This web is deeply notched on the upper edge in order to allow the passage of horizontal reinforcing bars. When a curved wall is to be built the tiles are made with their sides curved to the proper radii.

Fireclay tiles were used in the stack described, the sides and web being ¾ in. thick. New style Johnson corrugated steel bars were used. In the upper 50 ft. of the stack the vertical reinforcement is ¾ in. square bars on 12 in. centers, and the horizontal rings are ½ in. square bars on 18 in. centers. In the lower 50 ft. the vertical reinforcement is 1 in. square bars spaced 12 in. on centers, and the rings are ½ in. square and 9 in. apart. The concrete filling is composed of one part of Portland cement to three parts of clean, sharp, sand.

The stack was designed and built by the Atlas Construction Co., of St. Louis.

Dust Removal from Foundry Tumblers.

One of the dirtiest and most objectionable features of the average foundry is the tumbler barrel equipment in which castings are rattled for the removal of excess sand from the moulds and partial cleaning. The process is very dusty and noisy, and unless the tumblers are located at a considerable distance from the foundry they are a decided nuisance. In an attempt to alleviate these conditions, the Niagara Radiator Co. has recently installed at its North Tonawanda, N. Y., works, an exhaust equipment by which the dust is rapidly removed from the tumblers and a cleanly condition is made possible in the castings cleaning room.

An exhaust blower has its suction duct connected to casings enclosing each of the tumbler barrels, the fan discharging through the roof of the building. There are eleven tumblers served, which are located in a row on 7-ft. centers, and each is enclosed by a wooden casing with a large tight-fitting door on the front through which access is had to the barrel for charging with castings and their subsequent removal. Over the top of the casing there is a galvanized-iron hood through which connection is made to the exhaust ducts, while for the inlet the bottom of the boxing or casing, which is some 6 or 8 in. above the floor, is left open. Thus when the fan is in operation a strong exhaust is created through the casing which positively removes dust and dirt from the tumbler and also effectually muffles the greater part of the noise.

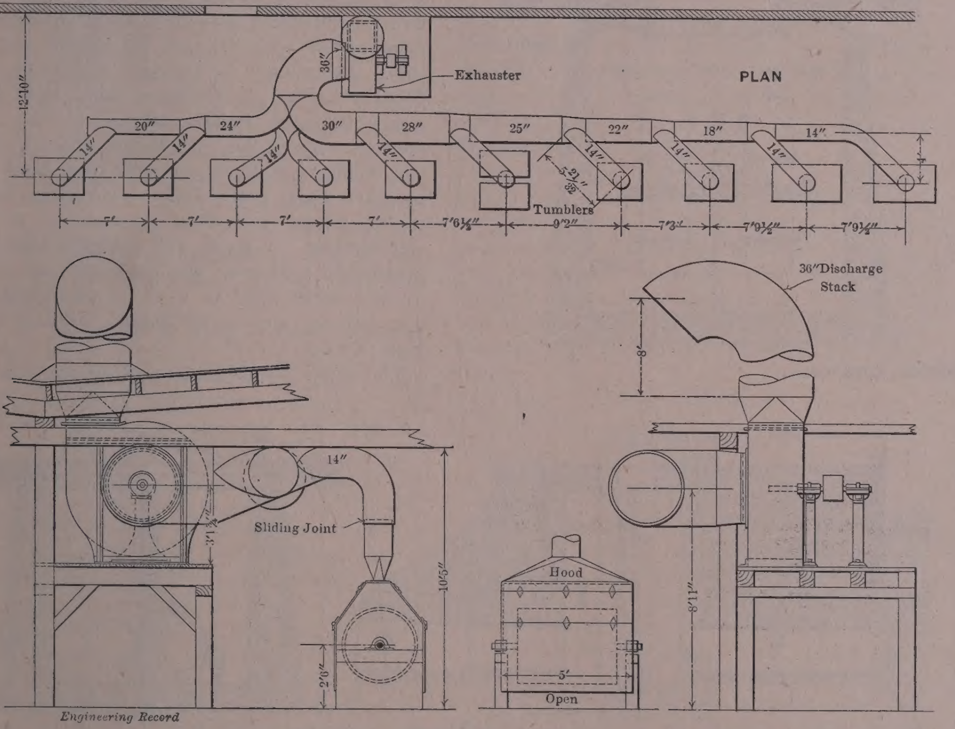
Connections are made from the tumbler casings to the exhaust fan through galvanized-iron circular ducts on the ceiling, with branches to each of the tumbler hoods. The branches to the hoods are 14 in. in diameter, the main duct enlarging in steps to 36 in. at the fan intake. Provision is made at one end for extension to connect with another tumbler, when desired. The entire duct system is supported on the ceiling entirely independent of the tumbler casings, and to prevent injury to the ducts from the jar and vibration of the tumbler barrels, each of the branches has a sliding joint connection to the hood of the casing.

The fan is a 70-in. steel plate exhauster with vertical discharge and a blast wheel 50 in. in diameter and 19 in. in width at the periphery. It has a 34½-in. inlet opening and discharges through a 36-in. outlet connection which is carried through the roof and terminates in a semi-circular discharge hood. The fan is belt driven from the tumbler drive shaft, and at a speed of 395 r.p.m. has a capacity of 11,000 cu. ft. per minute. It is capable of keeping the entire cleaning-room free from dust when all the tumblers are in operation. The exhauster equipment was designed and installed by the Buffalo Forge Co., Buffalo, N. Y.

Progress of the Erie Electrification Work.

Last summer the engineering firm of Westinghouse, Church, Kerr & Co. was retained by the Erie Railroad Co. to furnish and install on its Rochester division a complete electric motive power equipment for the passenger service of that portion of the main line of the division between Rochester and Avon and the branch between Avon and Mt. Morris, a total distance of about 34 miles of single track, besides sidings. Westinghouse, Church, Kerr & Co. immediately entered upon the work and have now brought it very near to completion.

The equipment which is now being installed, according to Mr. W. N. Smith of Westinghouse, Church, Kerr & Co., is the same system which was decided upon by the New York, New Haven & Hartford R. R. about a year ago, but that line will employ electric locomotives and haul trains of standard passenger coaches, while the equipment on the Rochester division of the Erie R. R. will consist of motor cars of the interurban type.



Dust Exhauster System for a Large Group of Foundry Tumblers

The supply of power for operating this electric system is to be derived from the lines of the Niagara, Lockport & Ontario Power Co., which receives the current generated at the new station of the Ontario Power Co. at Niagara Falls and is now transmitting it at 60,000 volts as far east as Syracuse where trolley cars of the local electric railway system are now receiving their power from it. This long transmission line, which is being constructed in duplicate, crosses the Erie R. R. at Mortimer, about five miles south of Rochester, and from that point the power company is constructing a branch line about 14 miles in length to a substation at Avon, 19 miles from Rochester and 15 miles from Mt. Morris.

The sub-station building of brick and reinforced concrete is now practically completed and the electrical apparatus which it is to contain is in process of shipment from Pittsburg. The equipment of this sub-station is extremely simple, consisting of three 750-kw. transformers of the oil-insulated, water-cooled type which transform the 60,000-volt, three-phase current down to 11,000-volt, single-phase current, which is to be fed directly to the trolley wires of the railroad. The usual accessory apparatus is also supplied, consisting simply of bus-bars, oil switches, choke coils and lightning arrester apparatus, together with the necessary pumps and piping for properly handling the insulating oil and cooling water into the transformers.

The overhead trolley construction, which is now well along toward completion, is of the so-called catenary type, which has been developed particularly for use with the single-phase system. The high electric tension involved in this system and the relatively large power supplied to the cars, and the high speed at which they are run, coupled with the necessity for absolute certainty of contact between wire and car has resulted in an arrangement of the trolley wire by which it is kept at an almost perfectly uniform height above the rail at all points without any perceptible sag, which greatly increases the smoothness of operation of the sliding type of trolley contact bar.

The catenary type of construction comprises a suspending or messenger cable of extra high-strength steel from which the trolley wire is hung at intervals of 10 ft. No matter what the sag is between the poles that support the messenger cable, the trolley wire, with which contact is made by hangers of varying lengths, is always maintained at an even height above the rail.

The trolley and messenger wires are supported by the bracket type of overhead pole construction. The poles are of heavy chestnut, averaging 8 in. in diameter at the top. The brackets consist of steel T-bars 10 ft. long, supported near the outer ends by two truss rods which reach up to the top of the pole, to which they are fastened by a new type of pole clamp designed expressly for this heavy work. The brackets are the heaviest ever erected for trolley construction. Upon the outer end of each bracket is mounted a heavy triple petticoat porcelain insulator, supported upon a malleable iron pin, which is bolted to the bracket. The insulator in turn supports the messenger cable.

Difficult problems were encountered at Avon and Rochester in supporting these trolley wires over the tracks through the railroad yards, and here again a new style of overhead span wire construction has been designed expressly to overcome the difficulty of carrying such heavy trolley construction through a railroad yard where it is impossible to place poles between tracks. In other places it has been found necessary to resort to steel bridges to accomplish this end, but the system of "tripartite" steel poles and double spans here adopted is believed to be fully as effective a type of construction as the former to meet the conditions, is far cheaper, and is much quicker to erect.

The bonding of the rails is now nearly completed, 80-lb. rails having been laid for the purpose of the electrification. An advantage of the single-phase system is that the cost of bonding for a railway equipped with it is much reduced below that for the same class of service with a direct-current system.

There are being provided six passenger coaches of the interurban type, about 54 ft. long and seating 56 people, which were built by the St. Louis Car Co., and are at the Buffalo shops of the Erie R. R., where the equipment is being applied. They have specially heavy trucks, the electrical equipment comprising four 100-h.-p. motors, one on each axle, besides the transformer above mentioned as part of the single-phase equipment, and the Westinghouse electro-pneumatic system of multiple unit train control. These cars will be capable of a maximum speed of from 45 to 50 miles an hour and will be able to haul one trailer under any of the conditions of service that are likely to prevail.

The trolleys mounted on these cars are of the so-called pantagraph type, consisting of a horizontal cross bar which makes the contact with the overhead wire and is raised or lowered by a light jointed framework suitably mounted on top of the car and insulated from it. It is controlled by air pressure and is designed to adapt itself instantaneously to any change in height of trolley wire as when passing under low bridges. This type of trolley, making sliding instead of rolling contact, obviates the annoyance experienced by the jumping of the ordinary wheel type of trolley at high speeds. Delays due to injury of the overhead construction by jumping of the trolley poles are also avoided and the certainty of continuous service is increased in proportion.

The cars will be ordinarily quartered at Avon under the care of the mechanical department in a special car house or inspection shed which is now under construction. This is to be of fireproof brick and reinforced concrete construction with kalomein windows and frames and rolling steel doors at each end, and is to be provided with requisite pits, hoists and transfer mechanism for readily effecting inspection and repairs at minimum expense. A suitable concrete pit is also being constructed at one side of the Rochester yard where the cars can be inspected while lying over at the terminal station.

The future of electric train propulsion over lines now operated by steam seems to be so full of promise that the Erie R. R. Co. have authorized Westinghouse, Church, Kerr & Co. to proceed at once with estimates for the complete electrification of the entire Rochester division between Rochester and Corning and work upon this is now being actively carried on. As will be seen by the foregoing account, the work of engineering construction on this electrification is now in a very advanced state of completion and it is confidently expected that the coming month of January will witness the first application of the single-phase system to a steam railroad.

LIMESTONE ROADS are reported to be unsatisfactory for automobile traffic in western England. The stone is soft, and the roads when damp are very slippery and dangerous for rubber-tired vehicles.

The descriptions are illustrated by photomicrographs showing the texture of the samples when magnified 27 diameters. After describing the characteristics of each sample, the general features of each group of rocks is discussed, and finally the authors draw from their experiments certain general conclusions regarding the stones best suited for road making. (London, St. Bride's Press, 24 Bride Lane; 5 shillings.)

In the Annual Report of the State Geologist of New Jersey for 1905 there is a paper by Mr. C. C. Vermeule on "Lake Passaic Considered as a Storage Reservoir for Potable Water, Flood Control and Utilization of the Passaic River." Probably there is no stream in this country which presents just now so many interesting problems as this, as was pointed out in a paper by Mr. M. R. Sherrerd in this journal on Dec. 1. It is not only necessary to take steps to prevent the disastrous floods which have occurred along the lower part of its course, but it is also highly desirable to find some method of storing the water so that it may be made useful. Before very long there will be a very large population in the portions of northern New Jersey which may be classed as suburbs of New York City, and the problem of supplying them with water will become an important one. Anything that will tend to conserve the water resources of this part of the State is therefore of much importance, and it is one of the peculiarities of the Passaic River flood problem that its solution probably solves, in a measure, the question of a future water supply. For nearly twenty years M. Vermeule has made a study of the river for the Geological Survey, and in the paper mentioned above he uses the results of these studies in explanation of the project of impounding the river waters by a dam at Little Falls, creating a lake of 51½ square miles. The project is explained in considerable detail, and an unusual method of financing it is suggested. In this same number of the report of the State Geologist there are several papers on aspects of the peat deposits in Northern New Jersey. The origin, occurrence and chemical composition of peat are explained by Mr. W. E. McCourt, the technology and uses of the material are described by Mr. C. W. Parmelee, who also supplies a paper on the testing and valuation of New Jersey peats, and there is also a paper by Mr. McCourt on the distribution of peat in Northern New Jersey. It appears from these papers that the material is mainly used in the manufacture of fertilizer, although there is one plant at Lincoln Park which makes peat briquettes that are sold at $3 a ton for local domestic fuel.

Mr. William Baxter, Jr., has recently prepared a description of "Switchboards" that will be welcome to the many engineers who have occasion to study their construction for the first time. In a general way it is probably true that switchboard design for most purposes is pretty well standardized and is not at all difficult to understand from the elaborate publications of the companies manufacturing such apparatus. Nevertheless the information furnished in Mr. Baxter's book cannot be obtained readily elsewhere, and as a comprehensive and clear explanation of switchboard principles and design has long been lacking in electrical literature, the volume will probably have a wide circulation. It is apparently written for technically educated men who are not electrical engineers. The introductory chapter explains the different types of generators and their windings and the different methods of distributing current, and points out the reason for the variety of types of switchboards. In the next chapter the method of operating generators in parallel is taken up, and the switchboard facilities for accomplishing it satisfactorily are described. The author then explains the general arrangement of the switches and instruments, and their connections with each other, with the generators and with the circuits. He attempts to lay down no general rules, but shows how particular problems have been satisfactorily solved, and thus furnishes a number of precedents on which the reader can base the solution of any problems of this sort that he may have. Among the boards shown are those of the Crescent Steel Works at Pittsburg and the Franklin Building in New York City. The construction of switchboards for large and small plants is next taken up and a large number of practical data are given. Up to this point most of the information in the book has related to direct-current work, and the alternating-current boards are explained in the next chapter mainly by pointing out the features in which they differ from those already described and by explaining the uses and connections of the instruments peculiar to alternating-current installations. Special sections of the book are given to boards for series alternating current arc lighting and for high-tension power transmission. In the second part of the volume the author describes the design and uses of different types of switches, circuit-breakers, and lightning-arresters, giving information that could not be introduced earlier in the book without complicating the explanation of the more general problems of switchboard design. The book is illustrated by a large number of diagrams and pictures of apparatus, and the author has very wisely adopted the principle of explaining his subject by illustrations as much as possible. (New York, Derry-Collard Co., $1.50.)

Letters to the Editor.

Engineering Design and Maintenance Charges.

Sir:—Some suggestions in a recent number of your journal concerning the importance of designing engineering structures with a view to balancing first cost and maintenance charges were duplicated in an address recently made by Mr. Donald A. Matheson before our local association of Students of the Institution of Civil Engineers. The speaker's important rank among Scotch engineers because of his position as chief engineer of the Caledonian Ry. and his long experience in the maintenance of railway works of all sorts lead me to send you a few notes of his remarks on the subject, as of possible interest to American engineers.

The importance of the subject was shown, he said, by the Board of Trade returns showing that over £30,000 are spent daily on the maintenance of railways in the United Kingdom. On a capital of about £1,100,000,000 invested in railways in the Kingdom, producing a gross annual income of about £113,000,000, only about £44,000,000 are available to the shareholders as dividends. The portion of the remainder devoted to maintenance charges is considerably over £10,000,000, and Mr. Matheson thought this annual expenditure could be reduced. In his opinion young engineers looking forward to careers as designers ought to spend some time in maintenance work and in studying the economics of maintenance in all its bearings. It is only by special study of the financial and other consequences of wear and tear and decay that the young engineer can acquire an appreciation of the eternal fitness of things in the selection of materials in connection with the design of civil engineering works. As an illustration of this subject Mr. Matheson mentioned a contractor's suggestion that a modification of the design of a steel bridge he was building would result in a considerable saving in its cost. The contractor was asked to consider carefully and report the next day how, in the future, the modified superstructure could be renewed at a reasonable cost without entirely stopping the road and railway traffic which passed over and under it. He never took the matter up again, for the bridge had been designed from the point of view of practicability in maintenance. Another suggestion made was to abandon squared rubble masonry for the facing of a sea-wall, and substitute concrete. The critic was told that the company preferred to face the wall then with rubble rather than have it ultimately faced with gold. That wall was designed and constructed from the point of view of cost in maintenance based on experience gained in the execution of remedial work in connection with another sea-wall which had been built with a concrete face, but which, in a few years after it was completed, failed to such an extent that its face had, practically, to be covered with sovereigns.

The notes you recently printed concerning the new experimental roadbed on the Pennsylvania R. R. were recalled to my mind when Mr. Matheson asserted that good drainage is in some degree synonymous with good dividends. In all civil engineering work, he said, the exercise of skill in properly dealing with water ultimately saves much money in maintenance. Most of the ills the civil engineer is professional heir to are attributable to the effects of water, and the speaker believed that, so far as maintenance is concerned, water is the greatest of the forces of nature with which the civil engineer must contend. It is not so much the impetuous flood and flowing tide that one has to guard against in the design of works as the terribly insidious and stealthy action of water, which never stops and inevitably results in decay.

Faithfully yours, Donald Cameron.
Glasgow, Nov. 22.

Plane Table Surveys.

Sir: I was very much interested in the letter in your issue of December 1st on plane table surveys, signed "Locating Engineer," but regret that more definite information was not given as to the kind of country, amount of wooded area, density of underbrush, etc., and, also, as to shape of area covered and dimensions of same. It goes without the saying, of course, that the plane table needs to be handled intelligently, just the same as any other tool, and for general topography is unquestionably better than anything else; the writer is convinced, however, from personal experience, that, for obtaining the topography required on surveys for the location of railroads, all things being considered, other methods are better and more economical.

The signature of your correspondent, as well as some of the statements in the letter, gives the inference that the work spoken of was railroad location, though the fact that ties (presumably of traverse lines) were made, seems to indicate that an area was being surveyed. The bald statement that the cost and quality of the work left nothing to be desired, does not allow of any comparison of your correspondent's experience with that of others.

Yours very truly, F. Lavis.
Hoboken, N. J.

Centrifugal Force has performed a miracle, according to testimony given in a damage suit against the Saginaw Valley Traction Co. some time ago. A passenger was standing on the rear platform, with his back against the door on one side of the platform. The car went around a curve and he claimed, and the jury and court have upheld the claim, that he was thrown toward the inside of the curve with such violence that he was not only hurled across the platform, but was also shot through the air some 10 ft. before he struck the ground. The laws of mechanics seem to be strangely inoperative in Saginaw.